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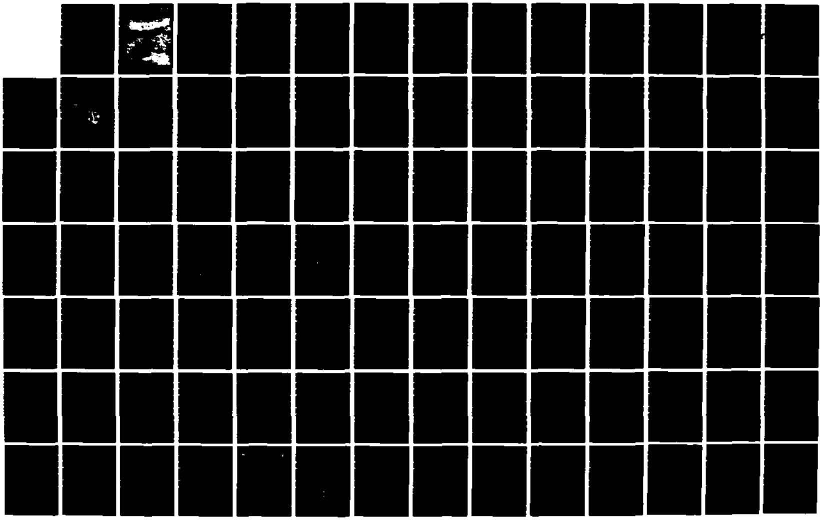

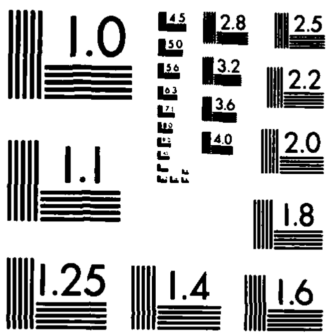

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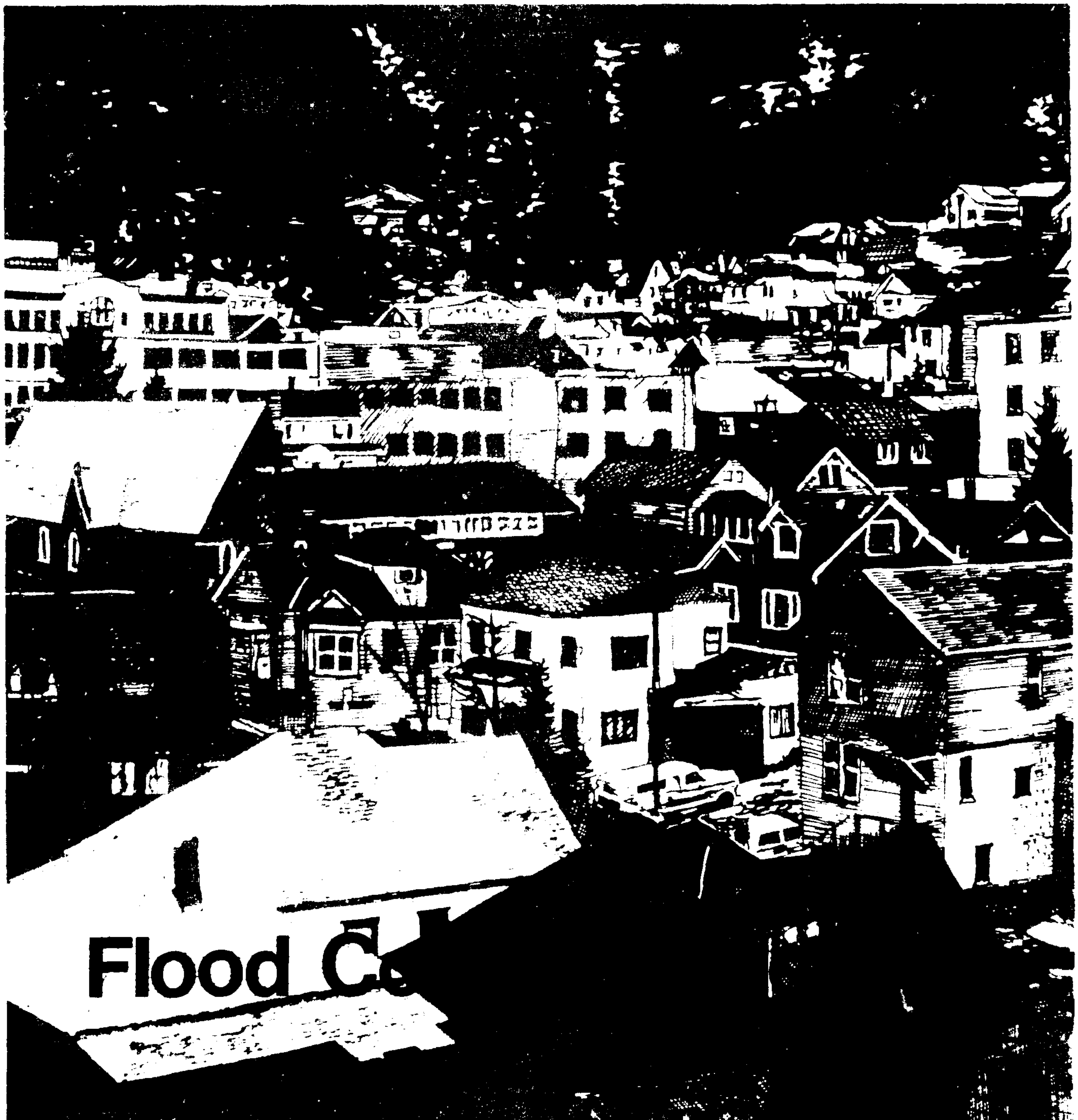

FARGO-MOORHEAD URBAN STUDY

FLOOD CONTROL APPENDIX

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The Fargo-Moorhead Urban Study is a cooperative Federal, State and local planning effort aimed at developing viable solutions to water and related land resource problems, needs and concerns for 1980-2030.

The summary report contains a brief, non-technical overview. Readers desiring additonal detailed information should review the appropriate technical appendixes.

This appendix is a detailed dicussion of the flooding problems in the study

area, alternative measures considered and the conclusions and recommendations made.

The study area encompasses 13 townships in Cass County, North Dakota and Clay County, Minnesota. Portions of the Red River of the North and the Wild Rice, Sheyene, Maple, Rush and Buffalo River drainage systems are in the study area.

FARGO-MOORHEAD URBAN STUDY

FLOOD CONTROL APPENDIX

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PREFACE

The Corps of Engineers urban study program is designed to provide planning assistance to local interests in a variety of water and related land resource areas, including water supply, waste-water management, flood control, navigation, shoreline erosion, and recreation. In areas of traditional Corps responsibility (such as flood control), the Corps may implement and construct projects shown to be feasible in the urban study. In other areas (such as waste-water management), Corps involvement carries only through the planning stage when findings are turned over to local interests for incorporation into their broad comprehensive urban planning effort. Implementation is at the discretion of local interests in conjunction with appropriate State and Federal agencies.

The St. Paul District, Corps of Engineers, sponsored the Fargo-Moorhead Urban Study as a cooperative effort between local, State, and Federal agencies. Part of this effort was a comprehensive investigation of the study area's flooding problems. This appendix discusses the flooding problems in the study area, the alternative measures considered, and the recommendations made.

This appendix is one of seven documents produced during the Fargo-Moorhead Urban Study. The other six documents include:

- Summary Report
- Background Information Appendix
- Water Supply Appendix
- Water Conservation Appendix
- Energy Conservation Appendix
- Fargo-Moorhead Water Resources Data Management System Appendix

The summary report is being distributed to all individuals, agencies, organizations, and special interest groups on the urban study's mailing list and to anyone else who requests a copy. The summary report provides an overview of the urban study, including:

- The study area
- How the study was conducted
- The study area's problems, needs, and concerns
- The final alternative solutions to these problems, needs, and concerns
- The findings and recommendations

Additional detailed information can be obtained from the appropriate technical appendix(es).

FARGO-MOORHEAD URBAN STUDY
FLOOD CONTROL APPENDIX

INTRODUCTION

The Fargo-Moorhead Urban Study was a cooperative Federal, State, and local planning effort aimed at developing viable solutions to water and related land resource problems, needs, and concerns in the study area for the period from 1980 to 2030. As part of the study, a comprehensive investigation of the study area's flooding problems was conducted. This appendix is a detailed discussion of the flooding problems in the study area, alternative measures considered, and the conclusions and recommendations made.

STUDY AUTHORIZATION AND PURPOSE

The Fargo-Moorhead Urban Study was an interim study, a part of the overall Red River of the North basin study. The study was authorized by a resolution of the Committee on Public Works, United States Senate, 93rd Congress, 2nd Session, adopted on September 30, 1974, at the request of Senator Quentin N. Burdick of North Dakota. The resolution requests that the Board of Engineers for Rivers and Harbors review prior reports on the Red River of the North drainage in Minnesota, South Dakota, and North Dakota to determine if any recommendations of those reports should be modified, with particular reference to flood control, water supply, waste-water management, and allied purposes.

DESCRIPTION OF THE STUDY AREA

STUDY AREA BOUNDARY

The study area for the Fargo-Moorhead Urban Study (see figure 1) encompasses 13 townships in Cass County, North Dakota, and Clay County, Minnesota. Major population centers in this area are Fargo, North

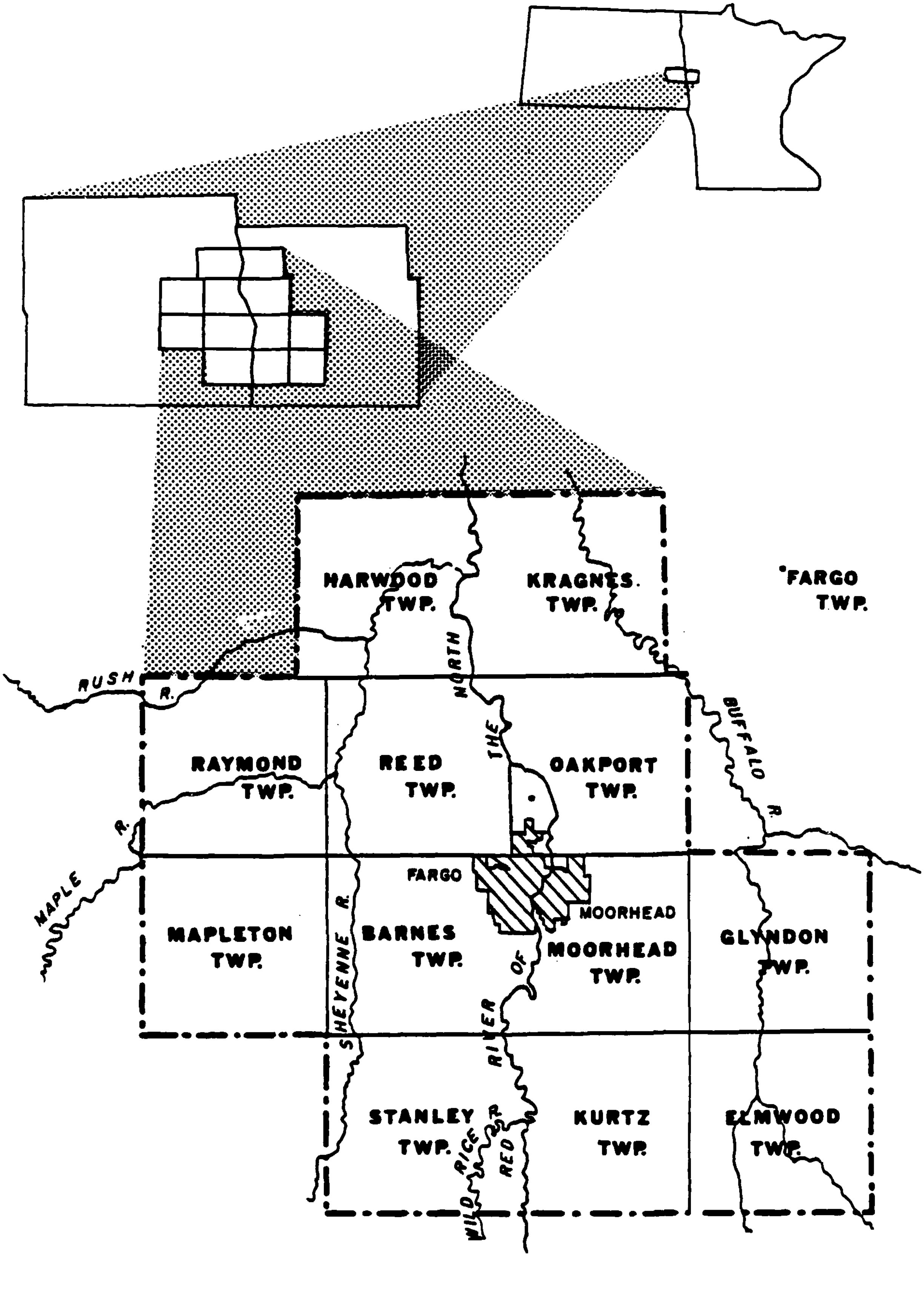


FIGURE 1
STUDY AREA

Fargo City Water Plant at river mile 453.0. The present reference datum elevation is 861.8 feet above mean sea level, 1929 adjustment. Flood stage is defined as 17 feet or elevation 878.8 msl, 1929 adjustment.

Damaging floods from snowmelt, high intensity rains, or a combination of both occur in the subbasin almost on an annual basis. Snowmelt floods result from snow accumulation over the winter months followed by rapid thaws in March, April, and sometimes early May. Because summer storms are generally localized, they usually do not affect the main stem area nearly as much as other subbasins; however, the July 1975 storm was an exception.

The following table identifies the floods of record at Fargo and Moorhead.

Table 2 - Floods of Record for Red River of the North at Fargo for Gage and Datum Then in Use.

Year	Month	Stage (feet)	Elevation (feet msl)	Estimated Peak Discharge (cfs)
1882	April	-	-	20,000
1897	April	-	-	25,000
1943	April	34.3	896.1	16,000
1947	April	28.9	890.7	9,300
1952	April	34.6	896.4	16,300
1962	June	28.4	890.2	9,600
1965	April	30.5	892.3	11,400
1966	March	30.1	891.9	10,700
1969	April	37.3	899.1	25,300
1975	July	33.3	895.1	13,200
1978	April	34.4	896.2	17,500
1979	April	34.9	896.7	17,300

River, and the Sheyenne River. This reach includes the urban study communities of Brooktree Park, Rivertree Park, Harwood, and Reile's Acres.

Table 1 - Observed Events Above a Stage of 16.5 Feet
Sheyenne River at West Fargo (1930-1979)

Maximum Stage		Discharge		
Date	Feet	Date	Peak (cfs)	Maximum Mean Daily Discharge (cfs)
5 Jul 1975	22.25 (3)	3 Jul 1975 (R)	2,850	2,850
21 Apr 1979	22.12 (3)	21 Apr 1979 (R)	3,480	3,480
16 Apr 1969	21.70 (3)	22 Apr 1969 (R)	3,060	3,030
22 Mar 1966	21.05 (2)	4 Apr 1966 (R)	3,110	3,100
29 Mar 1978	21.04 (3)	29 Mar 1978 (R)	1,660	1,650
19 Apr 1965	20.78 (2)	24 Apr 1965 (R)	2,530	2,530
11 May 1950	20.61 (2)	22 May 1950 (R)	2,810	2,800
18 Apr 1947	20.53	18 Apr 1947	2,800	2,800
9 Apr 1952	20.50 (2)	12 Apr 1952 (R)	2,510	2,500
1 Apr 1943	19.35 (1)	7 Apr 1943	2,400	2,400
12 Jul 1962	19.02 (2)	13 Jul 1962 (R)	2,420	2,410
20 Jun 1953	18.83 (2)	17 Jun 1953 (R)	1,300	1,270
7 May 1948	18.46	7 May 1948	2,650	2,620
20 Mar 1972	18.28 (1)	20 Mar 1972 (R)	1,560	1,490

(1) Backwater from ice. (2) Backwater from Maple River.

(3) Backwater from Maple and/or Red Rivers.

(R) = Regulated flows from Baldhill Dam from 1950 to the present.

Red River of the North

Records of river stage and discharge on the Red River of the North have been maintained since the year 1901. Early observations were taken on a nonrecording gage that was relocated or that had the datum adjusted several times in the period since 1901. Since April 13, 1959, a water-stage recorder has been used for continuous records. On October 1, 1960, the water-stage recorder was relocated to its present site at the

Sheyenne River

The surface water resources in the basin have been observed and used by man since early settlement. Estimates and records of water flow first began around the late 1800's when newspaper accounts of flood levels were made. The U.S. Geological Survey started systematic and continuous observation of flow at West Fargo in 1929, Valley City in 1938, Cooperstown in 1945, Kindred in 1949, and Lisbon in 1956. Miscellaneous other observations were made before that time. The urban study addresses the flooding problem along the Sheyenne River downstream of West Fargo at the communities of Reile's Acres, Harwood, Rivertree Park, and Brooktree Park. The closest gage is the one located at West Fargo, which is upstream of the confluence of the Sheyenne and Maple Rivers.

Early accounts of floods indicate that major floods occurred in 1882, 1883, and 1897. Newspaper accounts of the 1882 flood were found at Valley City and Fargo. Although no historical records of floods before 1882 have been found for the Sheyenne River, undoubtedly, floods did occur but may not have been observed or recorded. Table 1 summarizes observed events on the Sheyenne River at West Fargo. The 1969 and 1975 high water surface profiles along with selected high water elevations for other events are shown on plate 1.

All the floods listed in table 1 occurred in the spring except for the July 1975 flood. Snowmelt combined with rainfall during runoff was the principal cause of these floods. The July 1975 flood resulted from an intense rainstorm which remained centered over the lower basin for 3 days, dropping over 15 inches of rain in many areas.

Flood stages from the mouth of the Sheyenne River upstream through West Fargo are affected by backwater from the Red River of the North and Maple River. Thus, flood stages in this reach are usually greatest during the combined peaks of the Red River of the North, the Maple

DESCRIPTION OF EXISTING PROBLEMS

The Red River of the North is the principal source of flooding within the city limits of Fargo and Moorhead. The channel capacity of the Red River of the North in the Fargo-Moorhead area is approximately 7,000 cfs. Flows exceeding this capacity can inundate residential and commercial properties in both cities and can damage municipal facilities such as streets, bridges, and sewer systems. In addition, portions of the urban study area are susceptible to overflows from the Sheyenne, Maple, Rush, and Buffalo Rivers and numerous large county drainage ditches.

Over much of the area, floodwaters also frequently inundate rural areas during the spring snowmelt and after heavy summer rains with crops, farmsteads, and transportation facilities sustaining extensive damages. Although extensive damages occur to both urban and rural areas, the urban study focused only on urban flooding problems in the study area.

Present flood damages include both tangible and intangible losses. Tangible losses suffered during urban flooding include inundation damage to structures, utilities, and transportation facilities; flood-fighting costs; business losses; increased expenses for normal operating and living during a flood; dislodged fuel storage tanks and pipelines; and flooding of sewage collection and treatment facilities. Intangible losses include threat to human life, human misery, and potential health hazards from contaminated water and food supplies.

Under the limited flood protection presently available, tangible and intangible flood losses will continue on an increasing scale. Changes in the type and extent of flood damages would result from urban growth, community renewal programs, and land use shifts. Strict enforcement of and more stringent regulations in local floodplain management programs would help reduce the growth of future flood losses.

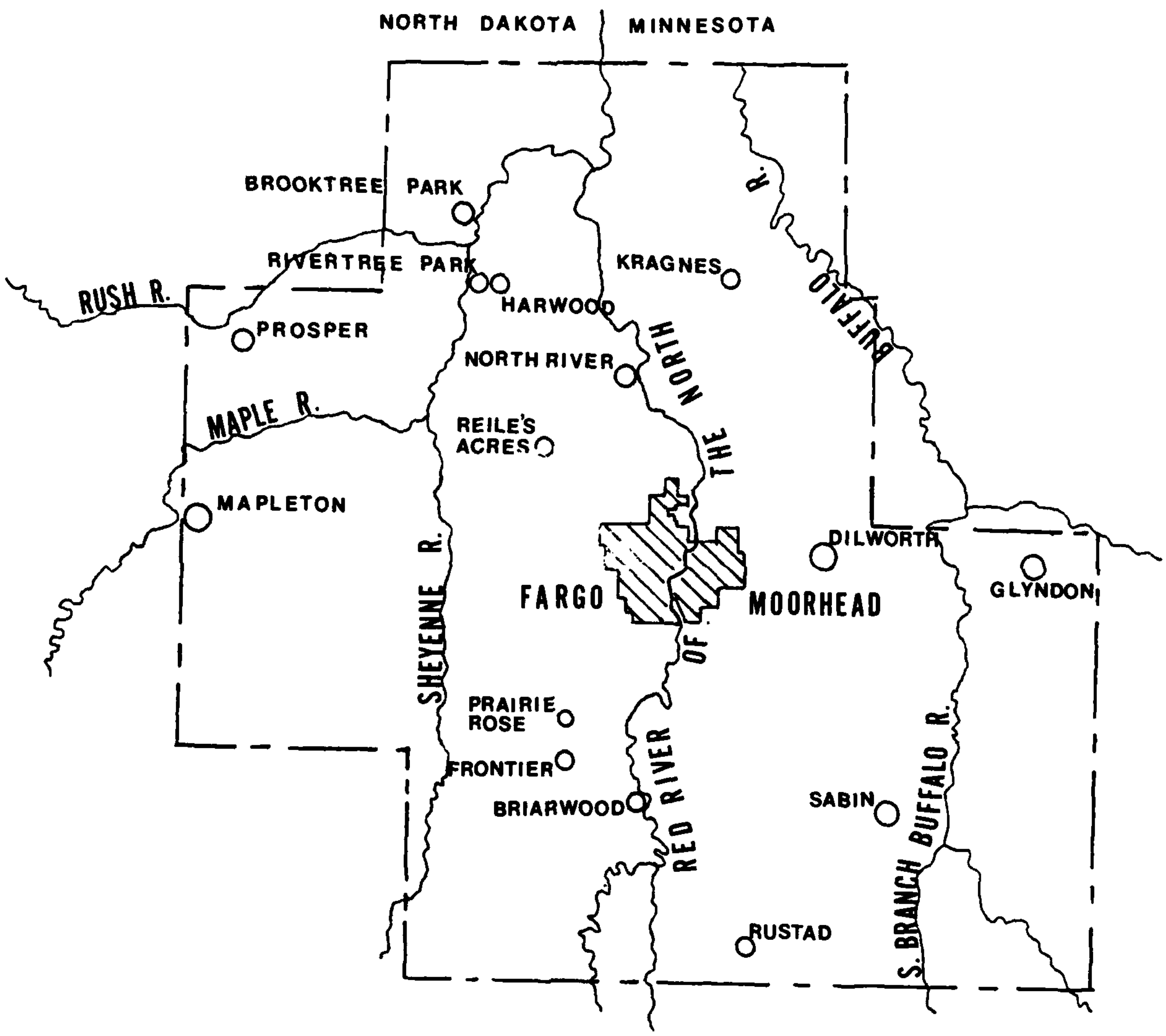


Figure 4

FARGO - MOORHEAD URBAN STUDY

FLOOD CONTROL STUDY AREA

CULTURAL ELEMENTS

Detailed information covering the history of the area, human resources, economy, and development was developed for the overall Fargo-Moorhead Urban Study. This information is in the Background Information Appendix.

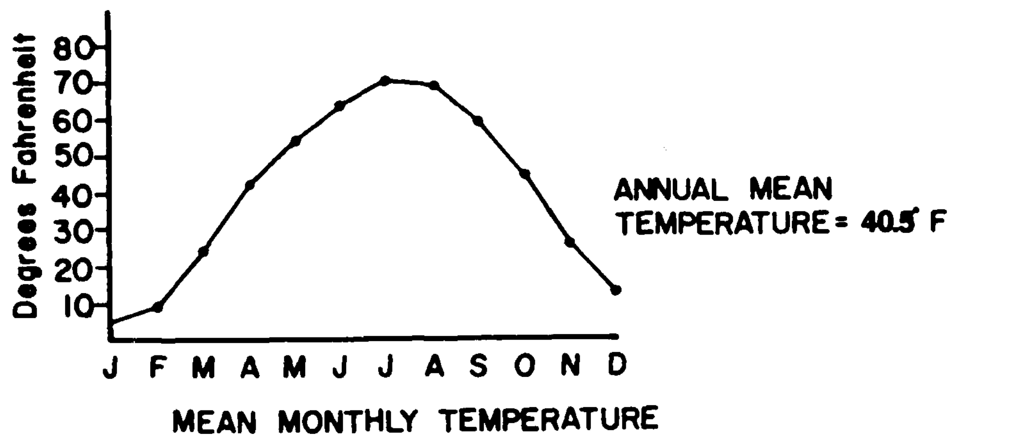
PROBLEM IDENTIFICATION

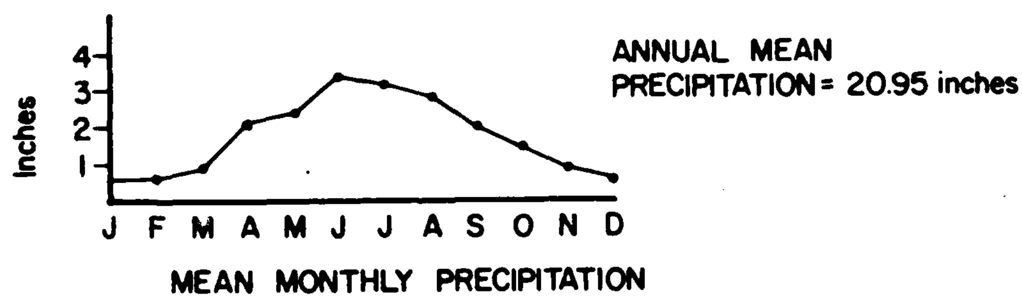
During this investigation, 17 communities within the study area were identified as having potential flood damages from various flooding sources. The following communities and their flooding sources are shown on figure 4: Fargo, Briarwood, Frontier, Prairie Rose, and North River, North Dakota, and Moorhead, Kragnes, and Rustad, Minnesota, from the Red River of the North; Brooktree Park, Rivertree Park, Harwood, and Reile's Acres, North Dakota, from the Sheyenne River; Sabin and Glyndon, Minnesota, from the Buffalo River; Mapleton, North Dakota, from the Maple River; Prosper, North Dakota, from the Rush River; and Dilworth, Minnesota, from localized drainage ditch runoff.

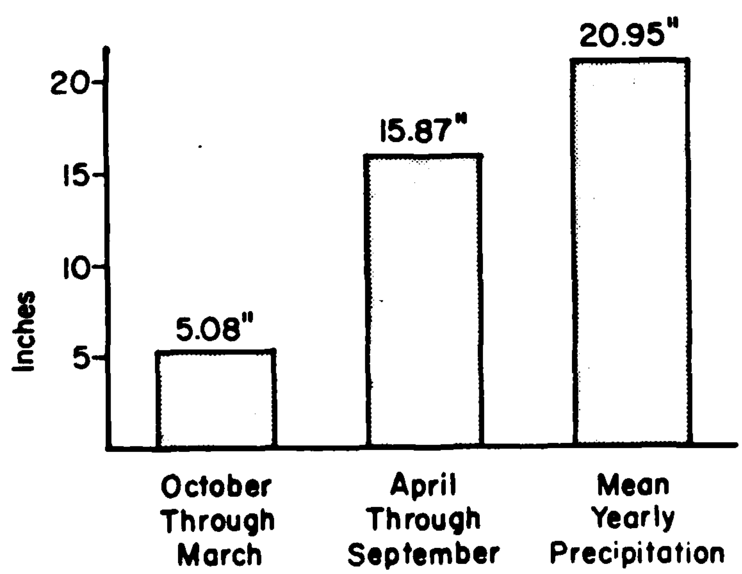
In addition to these 17 communities, three others - Horace, West Fargo, and Riverside, North Dakota - experience flooding from the Sheyenne River. The flooding problems of these three communities are addressed in a recently completed study entitled "General Reevaluation and Environmental Impact Statement for Flood Control and Related Purposes, Sheyenne River, North Dakota," January 1984, by the St. Paul District, Corps of Engineers. Argusville, which experiences flooding from the Sheyenne River, Red River of the North, and local drainage, is addressed in a recently completed report entitled "Detailed Project Report for Flood Control, Red River of the North, Argusville, North Dakota", January 1985, by the St. Paul District, Corps of Engineers. Unincorporated areas in the Fargo-Moorhead Urban Study area also experience flooding. This appendix presents data on flooding from the Red River of the North in Oakport, Moorhead, Barnes, and Stanley Townships.

FIGURE 3

MEAN TEMPERATURES AND PRECIPITATION
AT FARGO, NORTH DAKOTA







Channel catfish, walleye, sauger, and northern pike receive the greatest attention from anglers. Other species found in the Red River include carp, shiners, chubs, redhorse, bullhead, and largemouth bass.

The urban environment of the floodplain forest in Fargo-Moorhead provides little vegetational diversity. Small mammals, such as squirrels and rabbits, and a variety of birds are the predominant types of wildlife. White-tailed deer, fox, and raccoon are present in more heavily wooded corridor areas where development is not extensive. Numerous waterfowl pass through the study area during spring and fall migrations, using the scattered oxbow marshes and wetlands along the Red River. A more detailed discussion of the physical and environmental setting is in the Background Information Appendix, which is one of seven reports and technical appendixes constituting the Fargo-Moorhead Urban Study.

CLIMATE

The study area is in a region classified as "continental cool," typified by severe, cold winters and cool summers. The average temperature of the coldest month is below $32^{\circ}F$. The average temperature of the warmest month is between 50° and $71.6^{\circ}F$. On an annual basis, the prevailing wind at Fargo-Moorhead is from the north and northwest. The average annual temperature of $40^{\circ}F$ reflects the northern location of the area. Average annual precipitation in the Fargo-Moorhead area is about 21 inches. Nearly three-fourths of the annual precipitation occurs between April and September, with the remainder occurring during the winter. Mean temperatures and precipitation at Fargo, North Dakota, are summarized in figure 3. A more detailed discussion of the climate is in the Background Information Appendix.

terrain rises only 25 to 30 feet before becoming part of a plain that slopes toward the river at an average of 3 to 7 feet per mile.

Important wildlife habitat in the area includes any remaining grasslands or prairie, woodlands, and wetlands. Because of their location and scarcity, these vegetated areas are important to wildlife and for aesthetic considerations. Six major tree species form the core of the native riverbank forests: American elm, green ash, box elder, bur oak, basswood, and hackberry. Minor tree species include cottonwood, willow, ironwood, red elm, and trembling aspen. The most important shrubs in the area are wolfberry, gooseberry, virginia creeper, wild grape, chokecherry, and prickly ash. The ground cover is dominated by grasses, nettle, Solomon's seal, carrion flower, and meadow rue.

This riparian vegetation is very important because of its scarcity. Native woodlands provide habitat for many species of birds. Some characteristic breeding birds of the area are Cooper's hawk, red-tailed hawk, blackbilled cuckoo, great horned owl, yellow shafted flicker, blue jay, common grackle, mallard, wood duck, and ring-necked pheasant. Floodplain forests are also used extensively by passerine birds as migration corridors during the spring and fall.

The woodlands provide resting, feeding, breeding, and nesting habitats for a greater variety of wildlife than any other habitat type. They also afford migration and travel corridors for wildlife in the riparian zones of streams. Several species of tree squirrels and white-tailed deer depend on the woodlands for both food and cover. Most area carnivores, such as red fox, skunk, and raccoon, forage and often raise young in the woodlands.

The wooded riverbanks produce and enhance fish habitat by providing shade and temperature reduction, cover (tree roots and branches), and food (insects living in the trees and falling into the water). Seventeen families of fish containing more than 80 species are known to occur in the Red River; many other species are found in the tributaries.

Buffalo River

The Buffalo River originates in Becker County, Minnesota, which is just east of Clay County. It winds its way westward to a point just north of Dilworth, Minnesota, where it joins the South Branch of the Buffalo River. It then flows northwesterly, intersecting the Red River about 15 miles north of Fargo-Moorhead.

The drainage area of the Buffalo River is 1,040 square miles. The average discharge at the gaging station near Dilworth is 131 cfs, slightly less than that of the Sheyenne River. The maximum discharge of 13,600 cfs and maximum gage height of 27.1 feet were recorded on July 2, 1975. Zero flow was recorded occasionally in 1936.

Ottertail and Bois de Sioux Rivers

The Ottertail and Bois de Sioux Rivers join to form the Red River of the North about 100 river miles upstream of Fargo-Moorhead. Each river has a major reservoir - the Orwell Reservoir on the Ottertail River and Lake Traverse at the head of the Bois de Sioux River - that provides limited flow control for the Red River basin.

PHYSICAL AND ENVIRONMENTAL SETTING

The Red River of the North flows generally northward in the fertile Red River Valley, forming a meandering border between North Dakota and Minnesota. The river valley is the bed of former glacial Lake Agassiz. At its maximum extent, Lake Agassiz was about 700 miles long, 200 miles wide, and 650 feet deep. The Red River of the North drains into Lake Winnipeg in Manitoba, Canada. Lake Winnipeg is a remnant of Lake Agassiz.

The characteristic fertile soil and flat topography in this area are results of its glacial history. At Fargo-Moorhead, the river bottomland is very narrow, generally 1,000 to 2,500 feet wide, and the adjacent

longer than the Rush River and drains an area of 1,572 square miles. It flows in a southerly direction to a point west of Fargo, then northeasterly into the Sheyenne River at river mile 19.8. The slope of the Maple River is similar to that of the Sheyenne River; the slope of the Rush River is flatter.

The average flow of the Maple River at Mapleton, North Dakota, is approximately 72 cfs. On four occasions, the mean monthly flow has exceeded 1,000 cfs. The highest monthly mean is 1,708 cfs. Zero flow has been recorded many times. The Rush River has no gaging station within the study area. The nearest station is upstream of Amenia, North Dakota. At this point, 61 percent of the mean monthly flows are less than 1 cfs. Zero flows are a frequent occurrence, particularly in the months of August through March.

Wild Rice River (North Dakota)

The Wild Rice River begins in Sargent County, North Dakota. The river flows east into Richland County, then curves northward and parallels the Red River for about 100 miles. It passes through the southeast corner of Cass County and joins the Red River approximately 18 miles south of Fargo. The slope of the river ranges from 4.2 feet per mile in its upper reaches to 0.8 foot per mile over its last 100 miles. The Wild Rice Watershed encompasses approximately 2,020 square miles in southeastern North Dakota and 213 square miles in northeastern South Dakota.

The Wild Rice River's gaging station nearest the study area is east of Abercrombie, North Dakota, approximately 25 miles south of Fargo. Many periods of no flow have been recorded, primarily during winter. The average discharge during 47 years of records is 76 cfs. The maximum was 9,540 cfs on April 11, 1969.

of record, approximately 8 percent of channel capacity. The maximum recorded discharge was 25,300 cfs on April 15, 1969, almost 3.5 times the channel capacity. In contrast, no flow has been recorded on many occasions; the most recent occasion was on October 19, 1979.

Sheyenne River

The Sheyenne River is the second-longest river passing through the study area. It meanders approximately 500 river miles from central North Dakota to its mouth at the Red River of the North, 10 miles north of Fargo-Moorhead. The river flows in a southeasterly direction to a point southwest of the study area. At this point, it loops northeasterly and flows through the study area. The elevation of the headwaters near Kruger Lake is 1700 feet msl (feet above mean sea level); the elevation at the mouth is 854 feet msl. Thus, the river falls an average of 1.7 feet per mile.

The drainage area for the Sheyenne River is 5,290 square miles above West Fargo and 7,140 square miles above the mouth because the Rush and Maple Rivers join the Sheyenne between West Fargo and the mouth. The 7,140-square mile figure excludes the closed Devil's Lake basin and other closed areas, which total another 3,800 square miles. The channel capacity of the Sheyenne River at the West Fargo gaging station is 2,200 cfs, which corresponds to an elevation of 897 feet msl. The average discharge at this point is only 154 cfs, approximately 7 percent of channel capacity. The maximum recorded discharge was 3,480 cfs during the 1979 spring flood. At high flows, Sheyenne River floodwaters break out of the basin between Kindred, North Dakota, and West Fargo and join the Red River south of Fargo.

Rush and Maple Rivers

The Rush and Maple Rivers are tributaries of the Sheyenne River. The Rush River drains an area of 236 square miles. It enters the Sheyenne River from the west at river mile 11.7. The Maple River is considerably

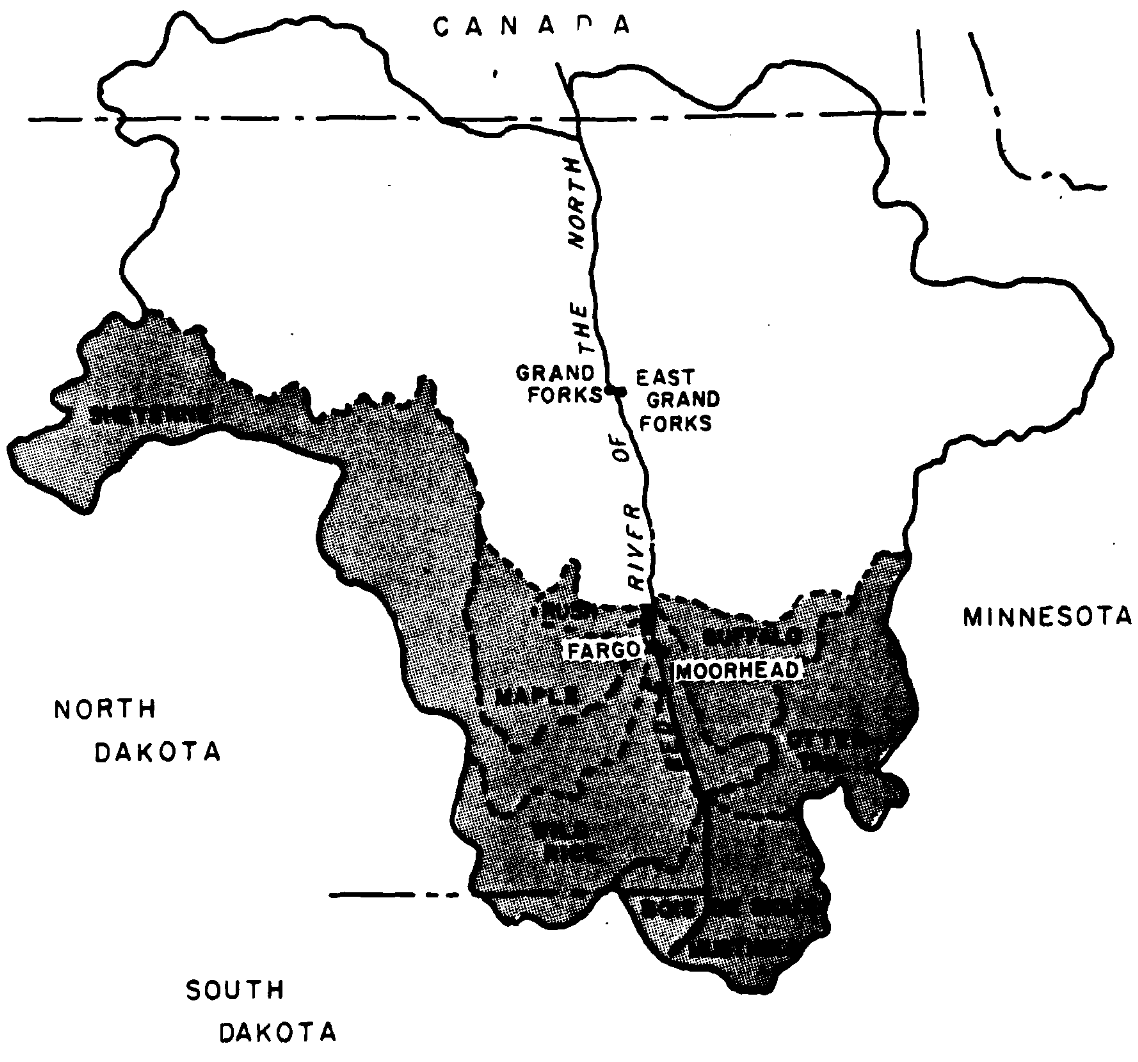


FIGURE 2
WATERSHED MAP

Dakota, and Moorhead, Minnesota. Fargo and Moorhead are on the west and east banks, respectively, of the Red River of the North, approximately 453 river miles above the mouth of the river at Lake Winnipeg. Study area boundaries were determined by distinguishing climatic, physical, biological, and socioeconomic characteristics that yielded common problems and goals.

The 13-township study area includes the cities of Fargo and Moorhead plus the surrounding townships in the Fargo-Moorhead projected 50-year urban growth area. Portions of the Red River of the North and the Wild Rice, Sheyenne, Maple, Rush, and Buffalo River drainage systems are in the study area. The relationship of the study area to the major watersheds is shown in figure 2.

MAJOR RIVERS

The major rivers in the study area include the Red River of the North and the Sheyenne, Maple, Rush, Buffalo, and Wild Rice Rivers. The Ottertail and Bois de Sioux Rivers merge upstream (south) of the study area to form the Red River of the North.

Red River of the North

The major surface water resource of the study area is the Red River of the North. It originates at the confluence of the Ottertail and Bois de Sioux Rivers near Breckenridge, Minnesota. It falls approximately 1-1/2 feet per mile to its outlet at Lake Winnipeg in Canada, 453 river miles downstream of Fargo-Moorhead. The Red River meanders through the former lakebed of glacial Lake Agassiz.

The drainage area of the Red River of the North at Fargo is approximately 6,800 square miles. The channel capacity at the Fargo gaging station is 7,000 cfs (cubic feet per second), which corresponds to a gage reading of 17 feet or elevation 861.8 feet msl (above mean sea level). The average discharge at Fargo is 559 cfs over a 78-year period

Maple River

The major cause of flooding on the Maple River is rapid snowmelt in combination with spring rains, or high-intensity rainfall. Flat topography and the large contributing western drainage area are factors that make almost all of Mapleton vulnerable to flooding. In addition to the flooding potential at Mapleton, the Maple River increases the flood problem on the Sheyenne River. Flows on the Maple River discharge into the Sheyenne River above the communities of Rivertree Park, Harwood, and Brooktree Park.

The maximum and most recent flood of record occurred in July 1975, with a discharge of 11,600 cfs. The April 1969 flood had a discharge of 7,000 cfs. Dates and discharges of major floods on the Maple River, as recorded at the U.S. Geological Survey gage at Mapleton, are listed in the following table.

Table 3 - Peak Discharges at Mapleton, North Dakota

Date	Peak Discharge (cfs)
April 1947	3,880
April 1950	1,980
April 1952	3,850
June 1953	4,850
April 1965	3,210
March 1966	3,610
April 1969	7,000
April 1970	3,340
July 1975	11,600

Snowmelt combined with rainfall during runoff was the principal cause of most of the Maple River flooding. The July 1975 flood resulted from an intense rainstorm that remained centered over much of the basin for 3 days, dropping over 15 inches of rain in many areas.

Rush River

Although the Rush River is characterized by an intermittent flow during much of the year, damaging floods from snowmelt, high-intensity rains, or a combination of both occur in the subbasin almost on an annual basis. About 80 percent of the time, floods are the result of snowmelt. Snow accumulation over the winter months followed by rapid thaws in March, April, and sometimes early May causes such flooding. About 20 percent of the time, the floods are the result of high-intensity summer storms.

The closest gage to the study area is located at Amenia, which is upstream of Prosper. The drainage areas at Amenia and Prosper are 116 square miles and 150 square miles, respectively. The gage at Amenia has been in operation since 1946. The largest flood recorded at the gage occurred on April 18, 1979. According to high water elevations observed, this was also the maximum flood recorded for Prosper.

Buffalo River

Flooding along the lower reach of the Buffalo River and its south branch occurs frequently. Most of the flooding is caused by spring snowmelt, sometimes intensified by rainfall. Besides spring snowmelt flooding, flooding can also be caused from high intensity rains during summer months, which was the case in July 1975. Although they do not occur very often, these summer floods are characterized by high peak flows.

As shown on figure 4, Glyndon is midway between the South Branch Buffalo River and the main branch of the Buffalo River. There is a gage located on the main branch of the Buffalo River at Hawley upstream of Glyndon. Two gages are located in the Buffalo River basin within the study area. One gage is on the South Branch Buffalo River at Sabin and another gage is near Dilworth on the main stem downstream of the confluence with the South Branch. The gages at Hawley and Sabin have been in operation since 1945, and the gage near Dilworth has been in operation since 1931.

The observed floods at these three locations are shown in the following table.

Table 4 - Observed Floods on the Buffalo River

	Discharge (cfs)		
Year	Hawley	Sabin	Dilworth
1975	2,050	8,500	13,600
1969	1,880	6,410	10,400
1962	1,430	6,340	6,140
1965	1,250	4,130	5,960
1978	2,000	3,440	5,420
1966	1,520	3,310	5,000

STUDIES PERFORMED

To help in the problem identification for the communities included in the study area, studies were performed in hydrology, hydraulics, and economics. These studies were performed to quantify the damages from historic floods and floods of greater magnitude that have the possibility of occurring within the study area.

Hydrology

Discharge-frequency data have been derived for several locations in and near the study area on the Buffalo, Sheyenne, Maple, Rush, and Red Rivers. Two types of frequency analysis have been done for the Fargo-Moorhead area. Both types used the data available from the U.S. Geological Survey (USGS) gaging stations on the rivers in the study area. The first type is P_{∞} (P-infinity), and is used for flood insurance studies (FIS) of the Flood Emergency Management Agency (FEMA). This is a Log-Pearson Type III analysis. Although these values were not used in the flood control studies conducted, they are presented in this report for the Sheyenne River and the Red River of the North because of the recent FIS work for the two rivers in the study area. The second type of frequency analysis conducted, which is used by the Corps of

Engineers in the design of flood control projects, is Pn (expected probability). This is also a Log-Pearson Type III analysis, but it has adjustments based on the length of record available. The reasons for the two sets of values are as follows:

1. It is considered to be easier to change P_{∞} values when a longer period of record is available since only flood insurance rates are involved (study by National Academy of Sciences, 1978).

2. Because it is very costly to modify flood control structures after they are built, a high level of confidence must be used in their design.

Because of these reasons, P_{∞} values are used in FEMA flood insurance studies, and Pn values are used in Corps of Engineers design work.

Red River of the North - Discharge-frequency data for the Red River of the North were developed at the gage near at the Fargo City Water Plant, at river mile 453.0. The period of record used in the analysis was 1901 to 1979, with historic information before 1901 used as available. The following table lists the discharge-frequency data for the Red River of the North at Fargo and also lists data downstream of the confluence with the Sheyenne River. The data in the table were obtained from a previous study entitled "Red River Study - Lower Sheyenne Frequency Analysis, 8-13 December 1982," by the St. Paul District, Corps of Engineers.

Table 5 - Red River of the North Discharge-Frequency Data

Exceedance Frequency in Percent (Return Period in Years)	Discharge in cfs			
	Fargo Gage		Downstream Sheyenne	
	P_{∞} Floodplain	Pn Corps Design	P_{∞} Floodplain	Pn Corps Design
10 (10)	10,300	11,100	15,300	15,700
2 (50)	22,300	24,900	31,800	34,700
1 (100)	29,000	33,300	41,100	46,100
0.2 (500)	50,000	60,800	68,400	82,700

Sheyenne River - Discharge-frequency data for the main stem of the Sheyenne River at Interstate Highway 29, which is downstream of the confluence with the Maple River, were obtained from a previous study entitled "Red River Study - Lower Sheyenne Frequency Analysis, 8-13 December 1982." The following table lists the discharge-frequency data for the Sheyenne River at Interstate 29.

Table 6 - Sheyenne River at Interstate 29 Discharge-Frequency Data

Exceedance Frequency in Percent (Return Period in Years)	Discharge in cfs	
	P_{∞} (Floodplain Use)	Pn (Corps Design)
10 (10)	6,250	6,510
2 (50)	13,600	14,400
1 (100)	17,500	19,000
0.2 (500)	28,900	33,200

The closest gage to the study area communities of Harwood, Rivertree Park, Brooktree Park, and Reile's Acres is on the Sheyenne River at West Fargo. The following table lists the discharge-frequency data for that gage. This information was obtained from a previous study entitled "General Reevaluation and Environmental Impact Statement for Flood Control and Related Purposes, Sheyenne River, North Dakota," January 1984, by the St. Paul District, Corps of Engineers.

Table 7 - Sheyenne River at West Fargo Discharge-Frequency Data

Exceedance Frequency in Percent (Return Period in Years)	Discharge (cfs) (Corps Design)
10 (10)	3,050
2 (50)	3,780
1 (100)	4,000
0.2 (500)	4,400

Maple River - Discharge-frequency data for the Maple River at Mapleton were obtained from the Sheyenne River study conducted by the Corps of Engineers. The following table lists the discharge-frequency data for the Maple River at Mapleton, a~suming Corps of Engineers design discharges.

Table 8 - Maple River at Mapleton Discharge-Frequency Data

Exceedance Frequency in Percent (Return Period in Years)	Discharge (cfs) (Corps Design)
10 (10)	5,330
2 (50)	14,900
1 (100)	21,900
0.2 (500)	49,300

Rush River - Discharge-frequency data for the Rush River at Amenia was obtained from the Sheyenne River study. Data for prosper has been estimated using drainage area transfer from Amenia. The drainage areas at Amenia and Prosper are 116 square miles and 150 square miles, respectively. The following table lists the discharge-frequency relationships for the Rush River at Amenia and Prosper.

Table 9 - Rush River Discharge-Frequency Data

Exceedance Frequency in Percent	Discharge in cfs	
(Return Period in Years)	Amenia	Prosper
10 (10)	1,390	1,630
2 (50)	3,660	4,280
1 (100)	5,230	6,120
0.2 (500)	11,200	13,100

Buffalo River - Discharge-frequency data for the Buffalo River were developed for three locations in and near the study area. The locations include the South Branch Buffalo River gage at Sabin, the main stem gage downstream of the confluence with the South Branch Buffalo River near

Dilworth, and the gage located on the main branch of the Buffalo River near Hawley, which is upstream of Glyndon. The following table lists the discharge-frequency relationships for the Buffalo River at these locations.

Table 10 - Buffalo River Discharge-Frequency Data

Exceedance Frequency in Percent (Return Period in Years)	Discharge in cfs Corps Design Values Hawley	Sabin	Dilworth
10 (10)	1,750	4,530	5,010
2 (50)	2,890	10,300	12,100
1 (100)	3,400	13,900	16,900
0.2 (500)	4,630	25,800	33,800

Hydraulics

Hydraulic studies were conducted to help determine the level of flooding within the study area. The following sections describe the type of studies and data used for each of the flood sources in the study area.

Red River of the North - The U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC-2 Water Surface Profiles) computer model was used to determine existing conditions water surface profiles on the Red River of the North within the study area. This model ties in with existing models previously developed by the Corps of Engineers for areas downstream and upstream of the Fargo-Moorhead urban area. The model was calibrated using historic flood profiles and discharges. Detailed cross-sectional information on the Red River of the North channel and overbank areas were obtained for this study. The locations of selected cross sections are shown on plates 2 and 3. Elevations for floods of selected exceedance frequencies at the selected cross sections are shown on the following table (table 11). Selected cross sections are shown on plates 4 through 13, with elevations of the floods of selected exceedance frequencies noted. Table 12 shows the elevations and stages

Table 11 - Red River of the North at Fargo-Moorhead
Water Surface Elevations Based on USACE Design Discharges
Updated Values as of December 18, 1984

Cross Section	River Mile Above Mouth	Channel Invert Elevation	Percent Chance Flood Elevation 10-PCT	2-PCT	1-PCT	.5-PCT	.2-PCT
70	436.02	854.0	884.0	892.0	893.0	894.1	895.2
69	437.63	855.0	884.7	892.5	893.5	894.5	895.5
67	438.74	855.0	885.3	892.9	893.8	894.6	895.2
66	439.18	856.0	885.7	893.5	894.7	895.7	897.2
65	439.35	855.0	885.7	893.5	894.8	895.7	897.2
62	441.25	858.0	886.5	894.2	895.6	896.6	898.3
61	441.88	857.0	886.8	894.4	895.8	896.9	898.5
59	442.63	856.0	887.0	894.6	896.0	897.1	898.7
54	444.16	855.0	887.5	894.9	896.4	897.5	899.1
52	445.03	859.0	887.6	895.0	896.4	897.4	898.9
48	446.18	860.0	887.9	895.3	896.8	897.9	899.5
47	446.66	860.0	888.1	895.4	896.9	898.0	899.4
44	447.35	860.0	888.4	895.7	897.2	898.4	899.9
43	448.09	860.0	888.7	896.0	897.5	898.7	900.1
42	448.35	859.0	888.8	896.1	897.7	899.0	900.5
39	449.10	861.0	889.2	896.6	898.2	899.6	901.2
38	449.29	862.0	889.4	896.7	898.4	899.8	901.4
37	449.98	863.0	889.7	897.0	898.7	900.1	901.6
35	450.83	857.0	890.2	897.4	899.1	900.5	902.0
32	451.56	866.0	890.8	898.1	900.0	901.6	903.3
29	451.73	863.0	891.0	898.3	900.3	902.2	904.3
27	452.48	866.0	891.3	898.6	900.6	802.5	904.7
26	452.68	868.0	891.4	898.8	900.7	902.7	904.9
25	452.92	871.0	891.7	899.0	901.0	903.0	905.2
23	453.38	866.0	892.0	899.3	901.3	903.3	905.4
21	454.22	865.0	892.4	899.6	901.6	903.6	905.8
19	454.94	863.0	892.7	899.8	901.8	903.7	905.8
17	455.46	864.0	892.9	899.9	901.9	903.8	905.9
15	456.08	864.0	893.2	900.2	902.2	904.1	906.2
13	457.21	865.0	893.6	900.5	902.5	904.4	906.4
12	457.38	864.0	893.6	900.5	902.5	904.3	906.3
11	457.88	863.0	893.8	900.7	902.6	904.5	906.5
9	458.81	865.0	894.3	901.1	903.1	905.0	906.9
8	460.40	868.0	894.9	901.6	903.5	905.2	907.0
7	460.62	868.0	895.1	901.8	903.7	905.4	907.1
6	461.23	867.0	895.4	902.1	904.0	905.8	907.4
5	462.09	868.0	895.9	902.4	904.3	906.0	907.6
4	462.68	864.0	896.2	902.6	904.5	906.2	907.8
3	463.10	867.0	896.4	902.8	904.7	906.3	907.8
2	463.32	866.0	896.6	903.0	904.9	906.5	907.9

at the Fargo gage for floods of selected return periods and historic events. The gage is located at river mile 453 near cross section No. 25. A rating curve for the Red River of the North at Fargo, North Dakota, is shown on plate 14.

Table 12 - Red River of the North Gage at Fargo
Comparisons of Floods of Selected Exceedance Frequencies
and Historic Events

Flood Event	Discharge (cfs)	Stage[1] (feet)	Elevation (Feet above msl)
Computed Values			
Exceedance Frequency in Percent (Return Period in Years)			
10 (10)	11,100	29.9	891.7
2 (50)	24,900	37.2	899.0
1 (100)	33,300	39.2	901.0
0.2 (500)	60,800	43.4	905.2
Measured Values			
1969 Flood	25,300	37.3	899.1
1978 Flood	17,500	34.4	896.2
1979 Flood	17,300	34.9	896.7

(1) Gage '0' = elevation 861.8.

Detailed topographic mapping was also developed for the Red River of the North floodplain through the urban study area. Maps were drawn at a scale of 1 inch = 200 feet and a 2-foot contour interval. A layout of the maps developed is shown on plates 15 through 17. Also shown on these plates is the project boundary where the actual contour mapping was done.

The study did not include the communities of Briarwood, North Dakota, and Kragnes and Rustad, Minnesota. Information for these three communities was obtained from the previous models developed upstream and downstream of the urban development of Fargo and Moorhead. The

following table presents the elevations at Briarwood, Kragnes, and Rustad.

Table 13 - Red River of the North
Flood Elevations Computed at Briarwood, Kragnes, and Rustad

Exceedance Frequency in Percent (Return Period in Years)	Elevation in feet msl		
	Briarwood, North Dakota	Kragnes, Minnesota	Rustad, Minnesota
10 (10)	897.6	884.3	903.0
2 (50)	904.2	889.6	908.9
1 (100)	905.9	890.3	910.3
0.2 (500)	908.8	892.0	912.6

Sheyenne River - Information for the Sheyenne River was obtained from a recently completed study entitled "General Reevaluation and Environmental Impact Statement for Flood Control and Related Purposes, Sheyenne River, North Dakota," January 1984, by the St. Paul District, Corps of Engineers. In the Sheyenne River study, rating curves were developed at key points along the Sheyenne River. The relationship between elevations and discharges is important at all locations along the Sheyenne River, but it is most critical and complex in the lower reach of the Sheyenne River within the study area. In this area, the levels of the Red River of the North and the Maple River influence the levels along the Sheyenne River. The following table summarizes pertinent rating curve data and locations along the Sheyenne River.

Table 14 - Summary of Pertinent Rating Curve Data
Along the Sheyenne River

Plate	Location	Reference Point
18	West Fargo	USGS gage
19 & 20	Mouth of Maple River	Railroad bridge over Sheyenne River
21	Brooktree Park, Rivertree Park, Harwood	I-29 bridge

Maple River - Flooding at Mapleton occurs when the Maple River reaches the elevation of County Highway 11 north of Interstate Highway 94. Floodwater will overtop the road and become sheet flow in the area east of County Highway 11 and north of Interstate Highway 94. The low point in the road obtained from surveys is elevation 906.5.

Flood elevations at Mapleton were developed for this study using historic profiles on the Maple River. The following table lists elevations for floods of selected recurrence intervals and for the 1975 flood.

Table 15 - Maple River at Mapleton

Comparisons of Floods of Selected Exceedance Frequencies and the 1975 Flood

Flood Event	Discharge (cfs)	Elevation (Feet above msl)
Computed Values		
Exceedance Frequency in Percent (Return Period in Years)		
10 (10)	5,330	905.7
2 (50)	14,900	907.2
1 (100)	21,900	907.5
0.2 (500)	49,300	908.0
Measured Value		
1975 Flood	11,600	906.8

Rush River - Information on the Rush River at Prosper was obtained from historic flood profiles. According to gage records at Amenia and high water elevations obtained at Prosper, the maximum flood occurred in April 1979. The discharge for the 1979 flood at Amenia was 3,490 cfs, which, according to the discharge-frequency data developed, was approximately a 2-percent exceedance frequency flood (50-year recurrence interval). According to high water measurements at Prosper, the 1979 flood reached an elevation of 898.7 at the railroad crossing. The railroad runs to the southeast along the southwest boundary of Prosper.

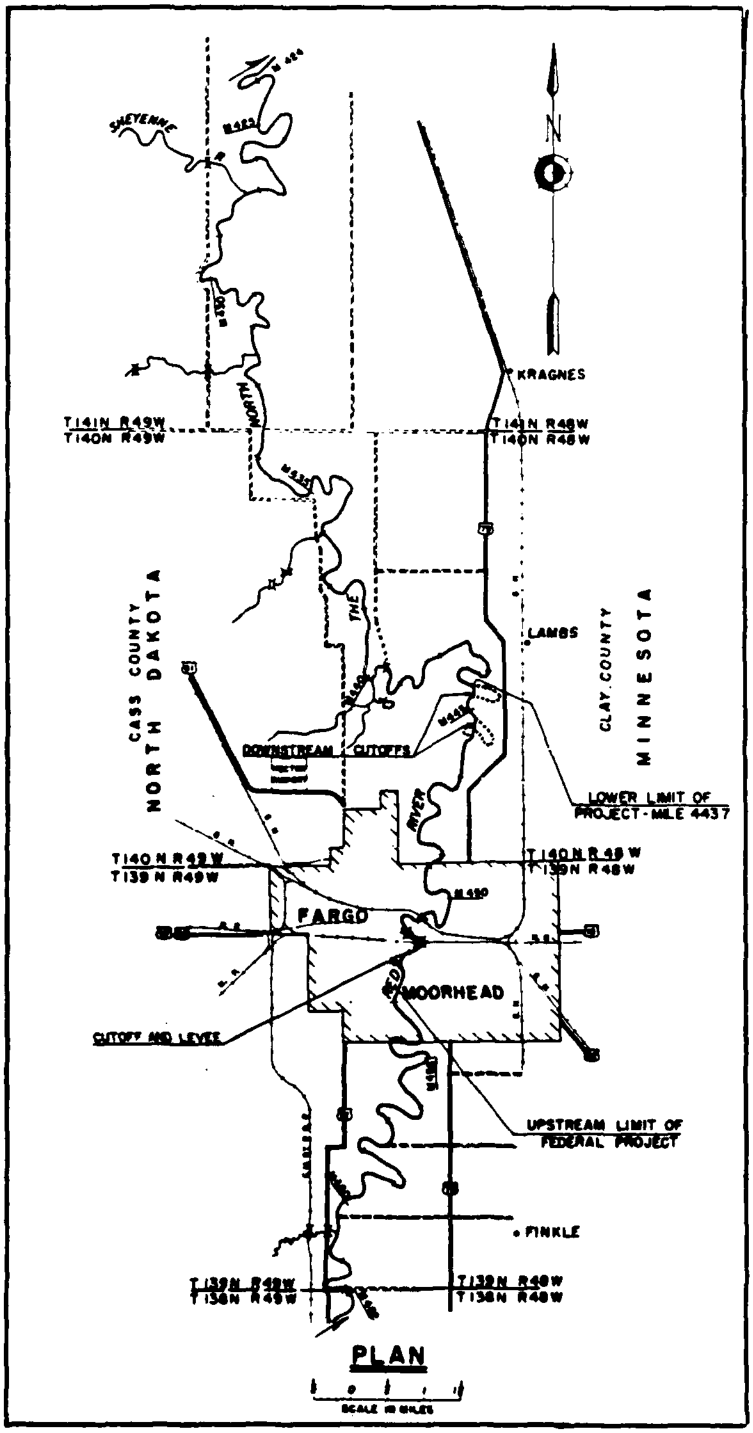
Buffalo River - Information on the Buffalo River was obtained from historic flood events. The maximum flood of record at Sabin occurred in 1975, with a discharge of 8,500 cfs and a recorded elevation of 922.3. The 1975 flood was approximately a 2.7-percent exceedance freqency flood (37-year recurrence interval).

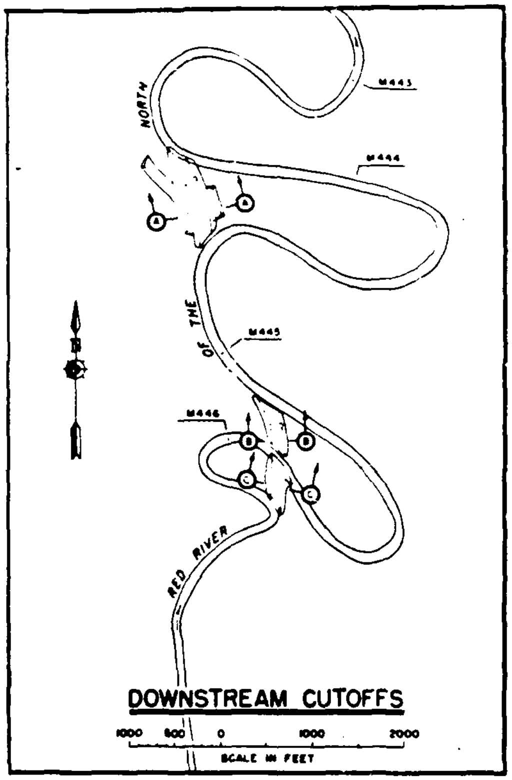
Information at Glyndon was based on the discharge-frequency data developed at Hawley and high water elevations recorded at the Highway 10 crossing of the main branch Buffalo River approximately 4 miles east of Glyndon. The maximum recorded flood at Hawley occurred in 1975, with a discharge of 2,050 cfs. The 1975 flood was approximately a 3.7-percent exceedance frequency flood (27-year recurrence interval) at Hawley and approximately a 2-percent exceedance frequency flood (50-year recurrence interval) on the main stem Buffalo River near Dilworth. The 1975 flood also had the highest recorded high water mark at Highway 10, with an elevation of 946.62. In 1969, an elevation of 946.12 was recorded. The 1975 flood had breakout to the west, with flows following Highway 10 into Glyndon.

The high water elevation on the South Branch Buffalo River at Highway 10 approximately 3 miles east of Dilworth was recorded to be 915.4. There is high ground between Dilworth and the South Branch Buffalo River. In addition to the high ground, the roads running north and south between the river and Dilworth are built up, acting as levees that block the flow of water which might break out to the west.

EXISTING FLOOD CONTROL PROJECTS

As part of the comprehensive plan for the entire Red River of the North drainage basin developed by the Corps of Engineers in 1947, a permanent flood control project was recommended and authorized for the Fargo-Moorhead area. This plan included 24 miles of channel clearing, channel enlargement and deepening for a distance of 4.9 miles, and construction





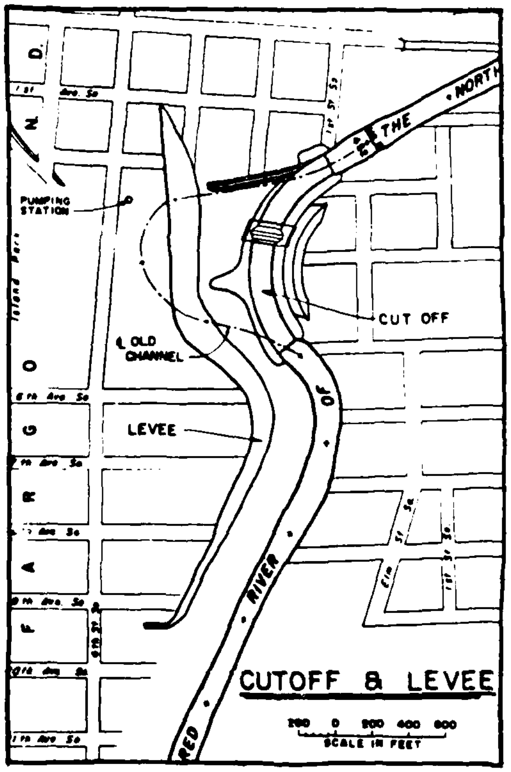


FIGURE 5

PERMANENT CORPS of ENGINEERS FLOOD CONTROL IMPROVEMENTS

FARGO - MOORHEAD

of 1,850 feet of earthen levee in Moorhead and 5,480 feet of earthen levee and concrete floodwall in Fargo. Several modifications were made to this plan on the basis of recommendations of local interests; in particular, the city of Moorhead indicated that it did not desire levee protection at that time. The project, as constructed (see figure 5 on previous page), consists of the following:

- 3,550 feet of earthen levee on the left bank of the river that protects Island Park and adjacent low areas in Fargo.

- A 1,200-foot channel cutoff in Moorhead across the river from Island Park and three smaller channel cutoffs approximately 7 river miles farther downstream. These cutoffs lower flood elevations slightly in both communities.

- Relocation of a low-head dam and extension of cooling water discharge lines from a nearby power plant, both necessitated by the channel cutoff in Moorhead.

- Appropriate ponding areas, outlets, and a pumping station for interior drainage.

The permanent flood control project was completed in 1961 and turned over to local interests in 1963. Some repair work was needed after the 1965 flood on the Red River; these repairs were completed by 1967.

In addition to the project described above, a section of private levee protects the Veterans Administration Hospital in Fargo. This 1,500-foot earthen levee has a central core of steel sheet pilings. Another private levee is located at Elm Street and Eighth Avenue North in Fargo and protects a condominium complex.

Fargo has a permanent levee protecting E.L. Zagal Golf Course. The city has also left three emergency levees in place at the following locations (see figure 6):

Table 17 - Economic Summary for Mapleton, North Dakota

Community: Mapleton
River: Maple River

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	27	54
Commercial	2	2
Public	1	1
Total	30	57

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	0	$252,000	$375,000	$660,000
Commercial	0	20,000	25,000	30,000
Public	0	8,000	10,000	12,000
Total	0	280,000	410,000	702,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 5-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation	906.5	905.7	907.2	907.5	908.0

Average Annual Flood Damages and Benefits

Annual Damages	$16,000
Annual Benefits of 100-Year Protection	8,000
Annual Benefits of 500-Year Protection	14,000

Table 16 - Economic Summary for Kragnes, Minnesota

Community: Kragnes
River: Red River of the North
River Mile: 432.7

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	4	7
Commercial	0	0
Public	0	0
Total	4	7

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	0	$13,000	$20,000	$45,000
Commercial	0	0	0	0
Public	0	0	0	0
Total	0	13,000	20,000	45,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 2.5-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation	889.5	884.3	889.6	890.3	892.0

Average Annual Flood Damages and Benefits

Annual Damages	$500
Annual Benefits of 100-Year Protection	250
Annual Benefits of 500-Year Protection	400

communities included in this screening process, information for the unincorporated areas along the Red River of the North are also shown. These areas are combined under Oakport, Moorhead, Barnes, and Stanley Townships and summarized in tables 20 through 23.

FINAL SCREENING

Flood control alternatives were then considered for those remaining communities that demonstrated average annual damages which could possibly support flood damage reduction measures. Management measures commonly considered include both structural and nonstructural.

Nonstructural

The following nonstructural plans were considered, but not evaluated in detail.

- Flood Warning Systems and Emergency Protection - This measure consists of predicting the timing and magnitude of floods and allowing for evacuation of flood-prone areas or erection of emergency flood protection measures. The National Weather Service provides rainfall and snowmelt advisory forecasts for the Red River and its major tributaries. It predicts a given stage at a particular gage or gages in the basin on the basis of observed precipitation and flow at upstream points as well as anticipated weather conditions. The forecast is transmitted to local officials, newspapers, and radio and television stations in the basin. These sources disseminate the information to residents of the floodplain in the form of a flood warning. Even though the anticipated flood may be of moderate proportions, forewarning permits industrial plants, public utilities, municipal officials, and individuals with property in the lowlands to take protective measures. Emergency flood protection barriers have been constructed during major flood periods in response to forecasts. These barriers are discussed on pages 28 through 36.

river mile 437.0. Also included in these inventories are the smaller communities of Prairie Rose, Frontier, Briarwood, and North River in North Dakota, and Kragnes in Minnesota. Reile's Acres, North Dakota, in the Sheyenne River floodplain was also inventoried.

The market value of each residential and multiple family structure was determined from city and county assessor records and adjusted to obtain the current market value.

The ground and first-floor elevations were inventoried to determine points where water would enter a building. Fargo has surveyed the lowest entry point and the first-floor elevations for most residences in the 100-year floodplain. Other structures were surveyed using a hand level and base maps that included the sewer system with manhole elevations along with elevations at the top of the curb for several points along each street. In some rural subdivisions, good survey maps were not available. Elevations for these areas were determined by USGS maps and supplemented by running vertical control to some of the areas. These areas were generally flat.

Three communities were surveyed along the Sheyenne River: Harwood, Rivertree Park, and Brooktree Park. The survey built on information provided by the Sheyenne River report. New information was collected to determine the value and elevation of new structures in the area. Damages determined from the new structure inventory were added to the updated damage figure reported in the Sheyenne River report.

Damages were also determined in Mapleton using USGS maps, county assessor's data, and supplemental elevations obtained by field surveys.

Based on the computed average annual flood damages, as discussed, a second screening of communities was made. Because of insignificant annual damages, the communities of Kragnes, Minnesota, and Mapleton, Frontier, and Prairie Rose, North Dakota, were eliminated from further investigations. Pertinent information used in the second screening process is summarized in tables 16 through 19. In addition to the four

Prosper

Prosper, North Dakota, is about a half mile east of the Rush River and is bordered by the Burlington Northern Railroad and a township road. Prosper is located on ground that is higher than the surrounding land in the area. The flood of record occurred in 1979 and reached an elevation of 898.7 at the Burlington Northern Railroad. This flood had an estimated exceedance frequency of 2-percent (50-year recurrence internal). Based on available information, the ground elevation at Prosper is approximately 900 feet msl, with the roads and railroad around the community being elevated. Because of the extremely infrequent flood potential in Prosper, further study was not warranted.

SECOND SCREENING

Following the initial screening of communities in the study area, a more detailed approach was required for the second screening which involved an economic evaluation of flood damages. This involved the development of average annual flood damages. These figures were derived by developing and combining hydrologic, hydraulic, and damage curves relating flood elevation and discharge, discharge and frequency, and flood elevation and damages. Discussions of hydrologic and hydraulic studies are in previous sections.

For the remaining communities considered in the second screening process, flooding can result from high stages on three rivers: the Red River of the North, the Sheyenne, and the Maple. Economic assumptions are based on an interest rate of 8-3/8 percent and October 1984 prices and conditions.

Structures in the estimated 0.2-percent exceedance frequency (500-year) floodplain of the Red River of the North were inventoried. This inventory included all structures in the floodplain within the corporate limits of Fargo, North Dakota, and Moorhead, Minnesota, as well as in the unincorporated areas upstream to river mile 466.5 and downstream to

Glyndon

Glyndon, Minnesota, is midway between the South Branch Buffalo River and the main branch of the Buffalo River. The main branch of the Buffalo River is the source of potential flood problems for the city of Glyndon. The maximum flood of record occurred in 1975 and reached an elevation of 946.6 at the Highway 10 bridge approximately 4 miles east of Glyndon. On-site inspection of Glyndon revealed that all houses are from 2 to 4 feet above road level. Discussions with city officials indicated that there are no problems with flooding in town. Review of past flood events indicates that, for infrequent events, some flow from the Buffalo River could break out and flow west along Highway 10 toward Glyndon. This break-out flow is not expected to pose a significant threat. Since a significant flood threat at Glyndon has not been identified, additional study was not warranted.

Dilworth

Dilworth, Minnesota, is about 3 miles west of the South Branch Buffalo River. The maximum flood of record occurred in 1975, reaching an elevation of 915.4 at the Highway 10 bridge. High ground between Dilworth and the South Branch Buffalo River and the elevated road system act as levees, blocking the flow of water that might break out to the west. On-site inspection and discussions with city officials reveal that the main concern at Dilworth is localized runoff handled by two drainage ditches. County Ditch 50, running east-west through the north part of Dilworth, has a drainage area of 1.9 square miles. County Ditch 41, also running east-west through the southern part of Dilworth, has a drainage area of 9.6 square miles. Because of the high water table and the problems with the local runoff that is handled by these county ditches, Dilworth experiences frequent surface flooding unless the ditches are kept open. Since the problem is related to localized drainage problems, it is not in the scope of a Federal flood control project and, therefore, further study is not warranted.

control project: Rustad, Sabin, Glyndon, and Dilworth, Minnesota; and Prosper, North Dakota.

Rustad

Rustad, Minnesota, is located about 1.5 miles east of the Red River of the North, upstream of the confluence with the Wild Rice River. The elevation of the land surrounding Rustad is approximately 910 feet msl. High water marks indicate that the 1969 flood of record at Rustad reached an elevation of 908.4 feet msl. As shown on table 13, the 2-percent and 1-percent exceedance frequency floods would reach elevations of 908.9 and 910.3 feet msl, respectively. At the 1-percent exceedance frequency flood level, much of the surrounding land would be inundated. The roads in the area are built up 4 to 5 feet above the normal ground levels, providing emergency transportation routes for Rustad. Based on the elevations of the structures and levels of flooding at Rustad, it was determined that there is not a significant flood problem that would warrant further study.

Sabin

Sabin, Minnesota, is about 1.5 miles west of the South Branch Buffalo River. The land immediately surrounding Sabin is the highest land in the immediate area and serves as the drainage divide between the South Branch Buffalo River to the east and the Red River of the North to the west. The elevation of the area of Sabin that would be affected by the South Branch Buffalo River is approximately 930 feet msl. The maximum flood of record at Sabin occurred in 1975 and reached an elevation of 922.3 as recorded at the gage east of town. The 1975 flood had an estimated exceedance frequency of 2.7-percent (37-year recurrence interval) and posed no threat to Sabin. Based on the elevations at Sabin compared to projected elevations of design floods from the South Branch Buffalo River, it was determined that there is not a flood threat which would warrant further study.

STUDY PROCESS

An initial analysis was conducted for Fargo, North Dakota, and Moorhead, Minnesota, and the 15 smaller communities to be looked at in the urban study area to determine which of these communities experience significant flood problems. Field inspections were made at each of the communities to determine the extent of development, elevations, and potential damage areas. Existing information was obtained from past floods to help determine which communities have been subject to flood damages. Based on this information, an initial screening process was performed. Communities that had no significant flood problems were eliminated from additional analysis.

For the remaining communities in the study area, estimated average annual flood damages were developed, as discussed in detail beginning on page 40. Based on these computed average annual flood damages, a second screening of communities was made. Communities that had insignificant annual damages were eliminated from further investigations.

Flood control alternatives were then developed for the remaining communities. Cost estimates were computed for each alternative; and, based on the average annual cost and the average annual damages prevented, a benefit-cost ratio was computed. Alternatives with a benefit-cost ratio greater than 1.0 (benefits derived from flood protection exceed the cost of the project) would be recommended for further, more detailed studies to determine the feasibility of permanent protection.

INITIAL SCREENING

Based on available information, communities that had no significant flood problems were eliminated from additional analysis. The following communities did not have significant flood problems that could require or economically justify further consideration of a permanent flood

	REACH 1	REACH 2	REACH 3
ELEVATION 1929 DATUM	908.6	906.5	
TOTAL LENGTH	1100'	3500'	
AVERAGE TOP WIDTH	12'	2'	
AVERAGE HEIGHT	4'	2'	
MAXIMUM HEIGHT	5'	2.5'	
EXISTING CULVERTS	—		
SIDE SLOPES	1:1.5	RIVERWARD LANDWARD	

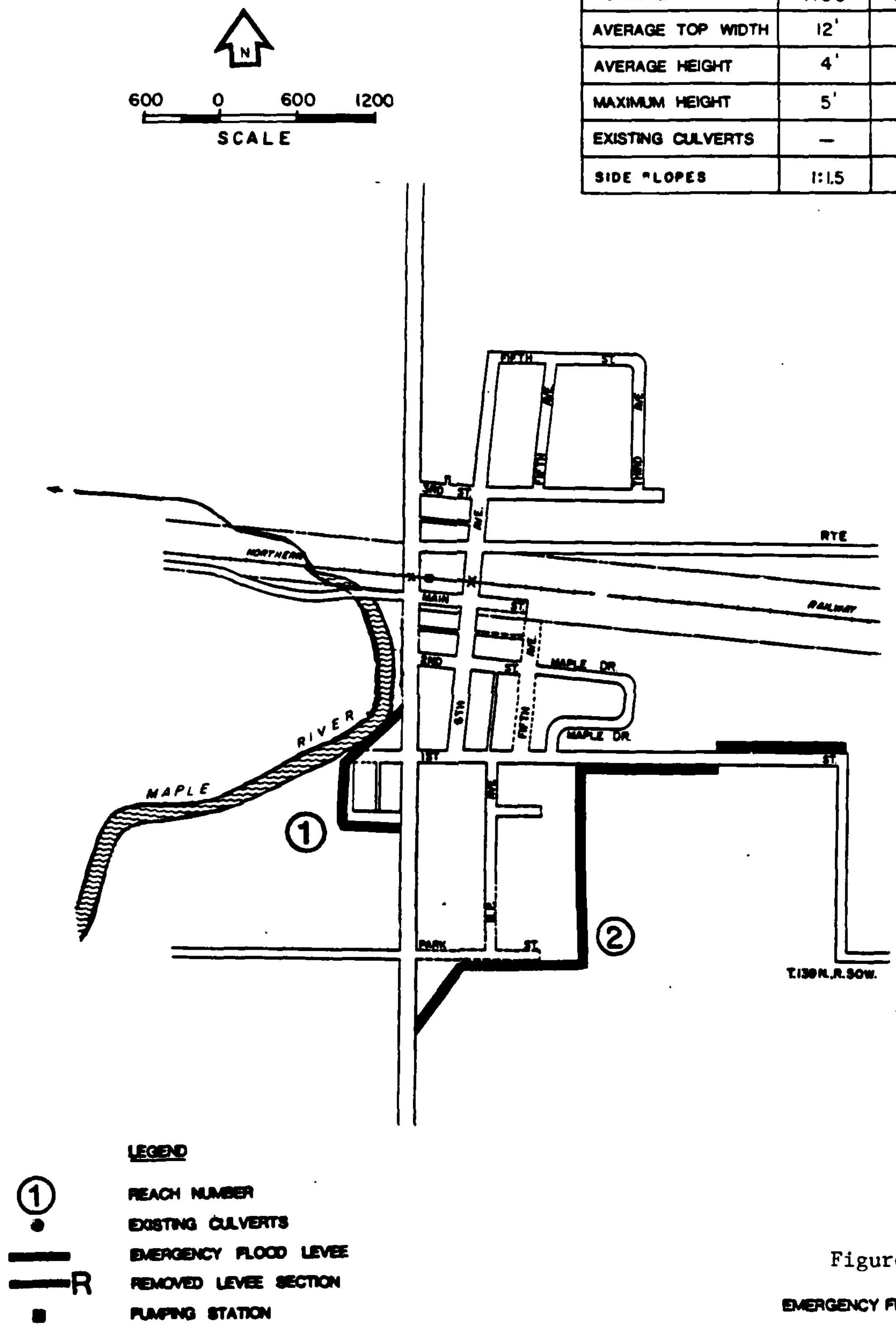


Figure 10

EMERGENCY FLOOD LEVEE

MAPLETON

CASS CO., NORTH DAKOTA

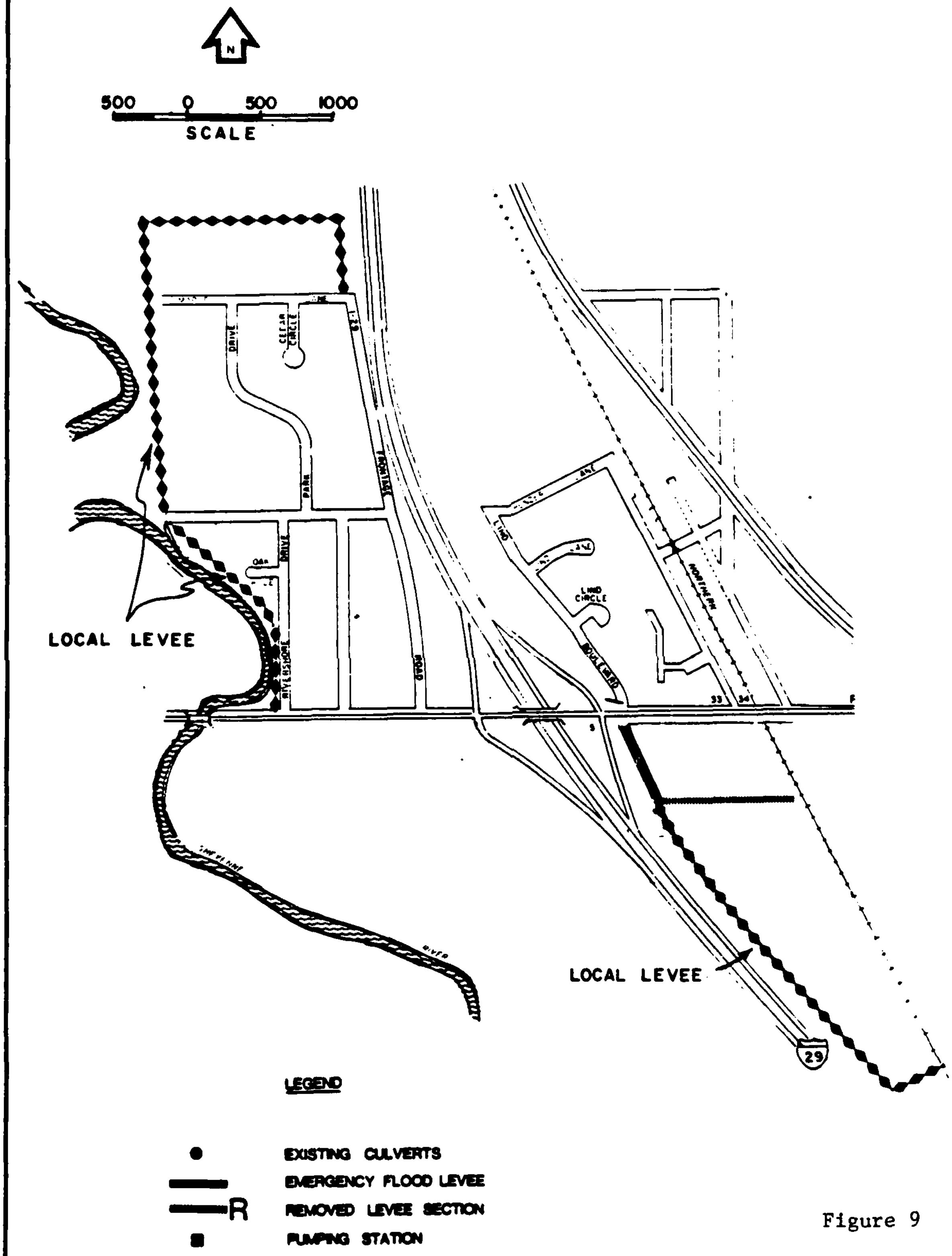


Figure 9

EMERGENCY FLOOD LEVEE

HARWOOD AND RIVERTREE PARK

CASS CO., NORTH DAKOTA

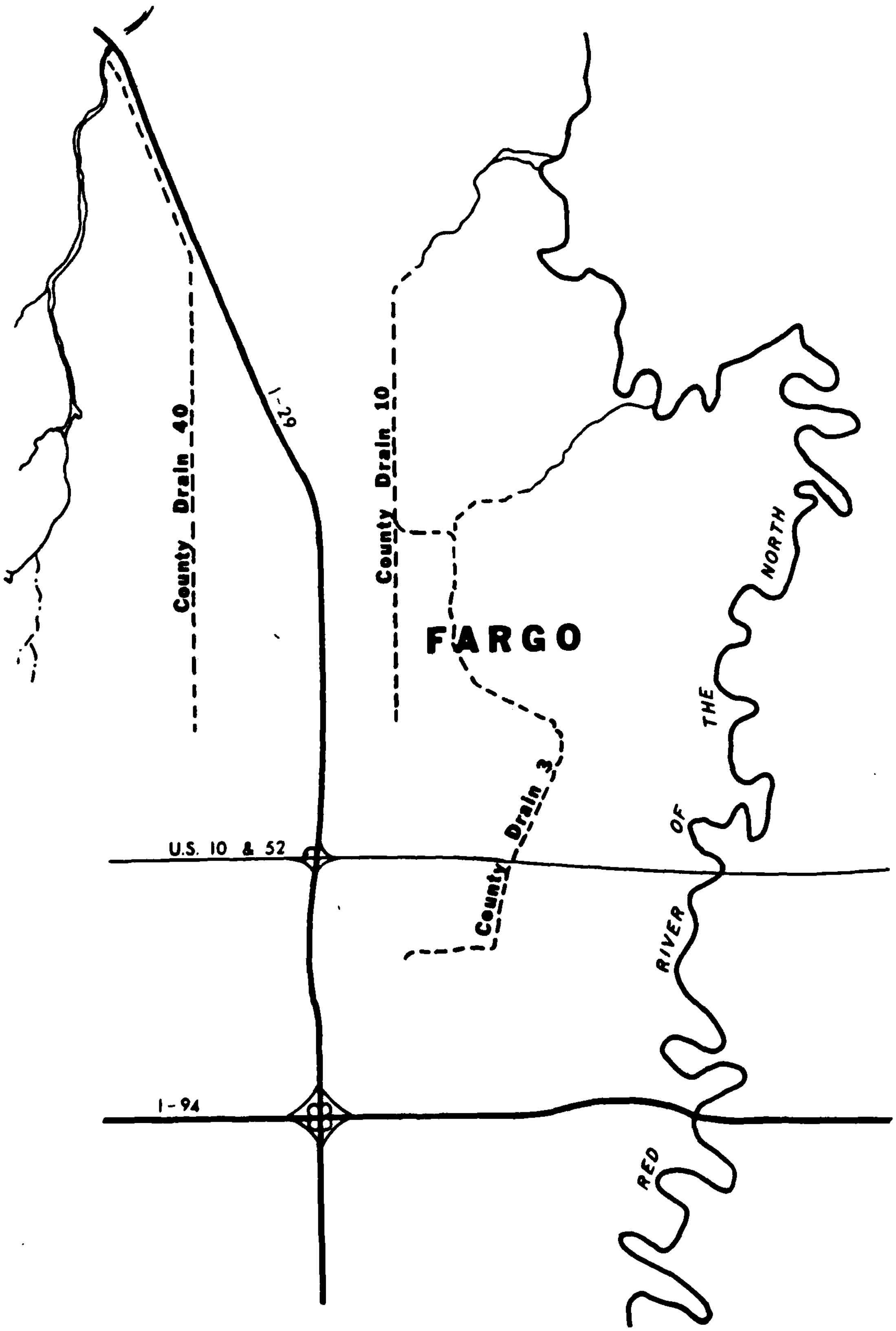
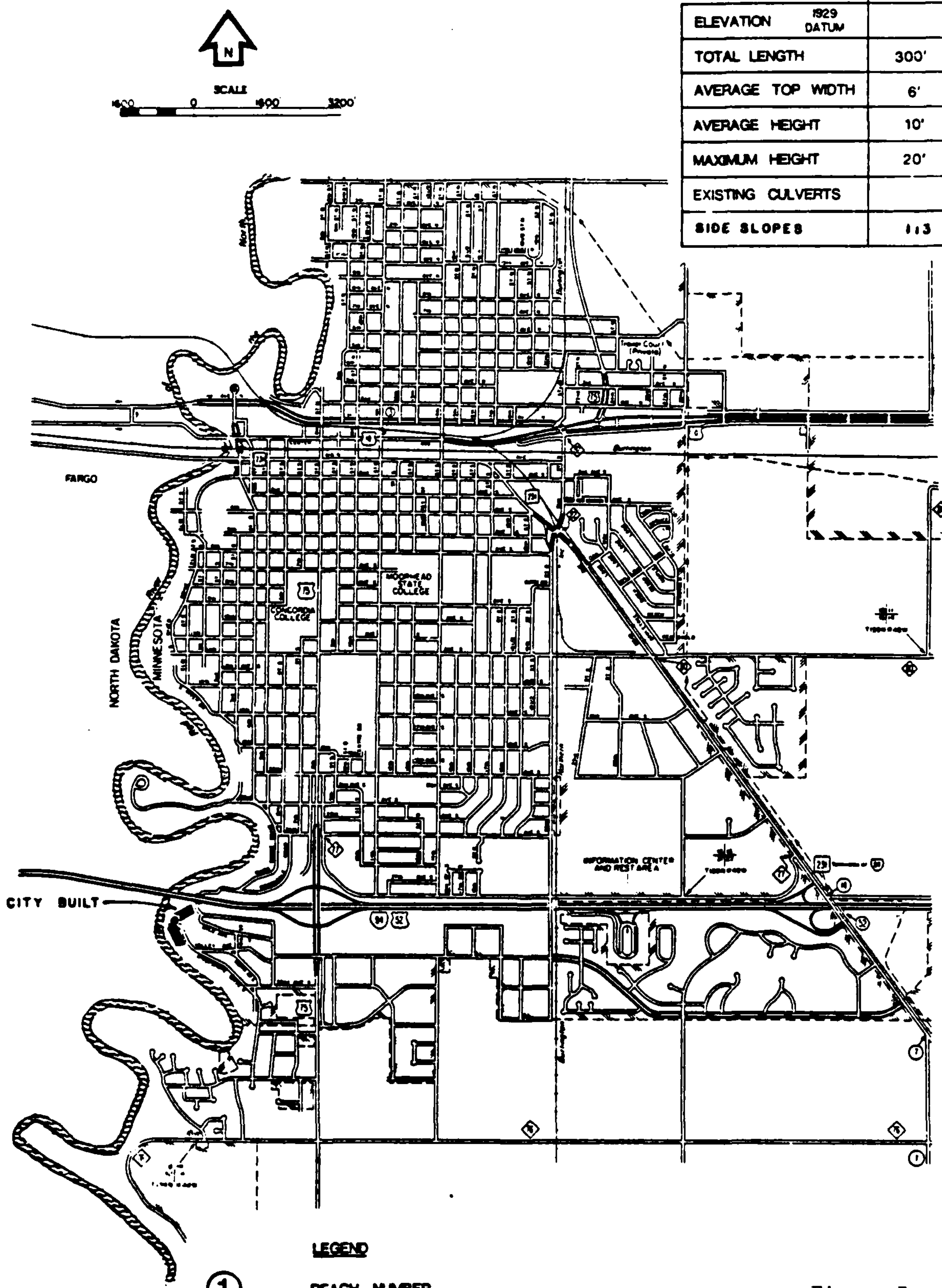


Figure 8

LOCATION MAP of COUNTY DRAINS 3, 10, & 40

	REACH 1	REACH 2
ELEVATION 1929 DATUM		
TOTAL LENGTH	300'	
AVERAGE TOP WIDTH	6'	
AVERAGE HEIGHT	10'	
MAXIMUM HEIGHT	20'	
EXISTING CULVERTS		
SIDE SLOPES	1:3	



LEGEND

① REACH NUMBER

● EXISTING CULVERTS

EMERGENCY FLOOD LEVEE

R REMOVED LEVEE SECTION

■ PUMPING STATION

Figure 7

EMERGENCY FLOOD LEVEE

MOORHEAD

CLAY CO. MINNESOTA

- o Along Elm Street from 18th Avenue to 19th Avenue North.
- o Along Oak Street from 8th Avenue to 10th Avenue North.
- o Along the riverbanks from 10th Avenue to 13th Avenue South.

No permanent flood control levees exist in Moorhead. A temporary levee was constructed during the 1978 spring flood on the Red River and was extended by the city in 1979. This area is adjacent to Gooseberry Park and just south of the Interstate Highway 94 bridge (see figure 7).

During the 1969 flood, three legal drains in Fargo were the source of considerable problems. Plans for improvements of drains 3, 10, and 40 (see figure 8) were completed in 1971, and construction began in 1976. The plans called for widening and deepening, lining with concrete, installing lift stations, and incorporating holding ponds. The drain improvements have already resulted in removing most of the land near drain 3, which runs through a developed area, from the 100-year floodplain.

Emergency levees exist at some of the smaller communities in the study area. A 1,300-foot emergency levee was constructed in the spring of 1979 around the southwest part of Harwood (see figure 9). A portion of this levee was removed and the city extended the levee as shown in the figure. The community of Rivertree Park constructed a levee to provide emergency flood protection from the Sheyenne River. The northern half of this levee is a raised gravel road, and the remainder is a mowed grass levee (see figure 9). An approximately 21-inch overnight rise in the Maple River during the spring flood in 1978 prompted the city of Mapleton to construct an emergency levee (reach 1 shown on figure 10) with Corps assistance. In 1979, another levee section (reach 2) was built because of concern that Highway 11 would be overtopped. No known levees have been built at any of the small Minnesota communities in the study area.

	REACH 1	REACH 2	REACH 3	REACH 4
ELEVATION	896.0	895.3	897.0	
TOTAL LENGTH	650'	1200'	1400'	
AVERAGE TOP WIDTH	6'	34'	4'	
AVERAGE HEIGHT			6'	
MAXIMUM HEIGHT			8'	
EXISTING CULVERTS	1-54"	1-66"	1-21" 1-36"	
SIDE SLOPES	1:4	1:4	RIVERWARD LANDWARD	

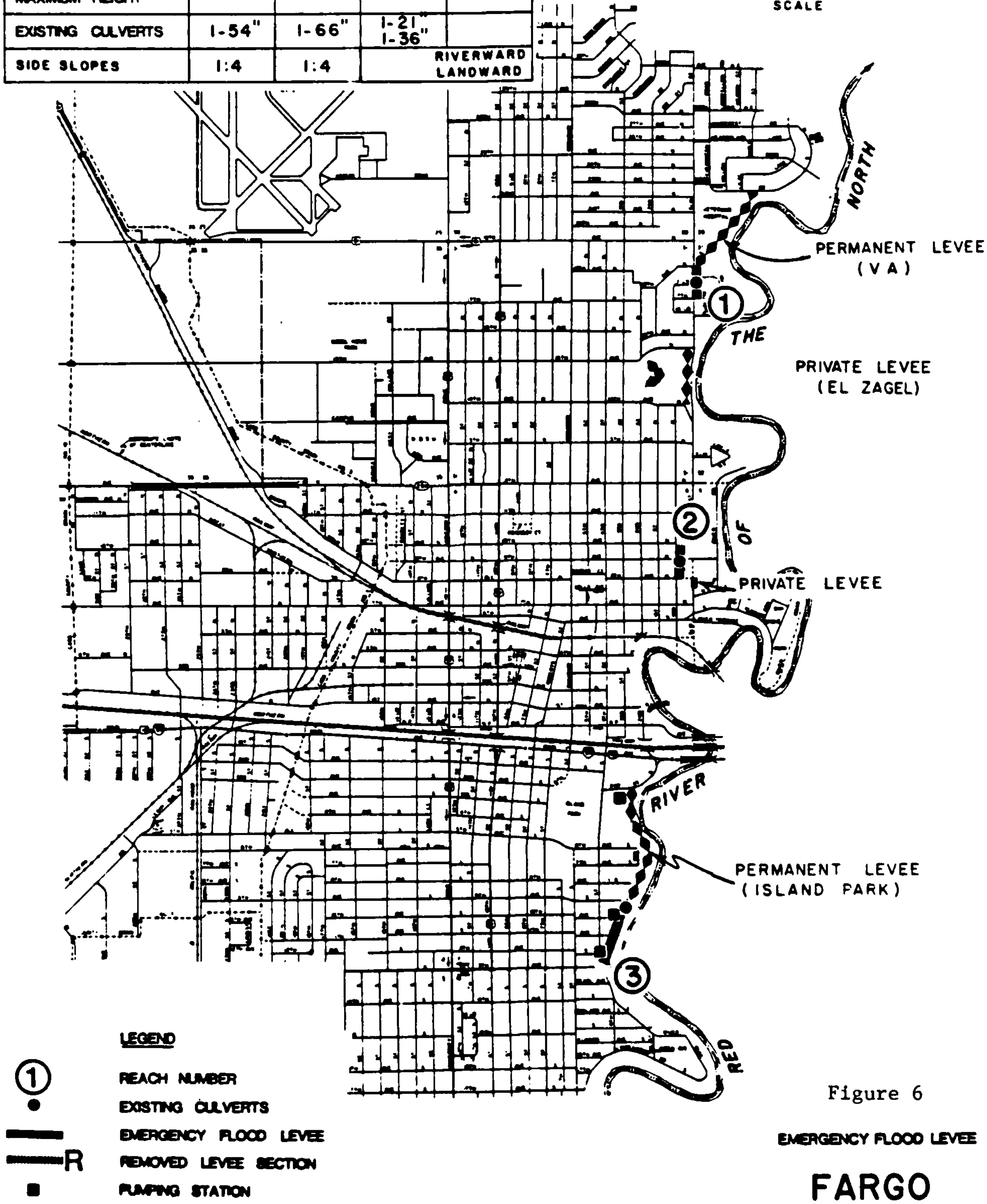


Figure 6

EMERGENCY FLOOD LEVEE

FARGO

CASS CO., NORTH DAKOTA

Table 18 - Economic Summary for Frontier, North Dakota

Community: Frontier
River: Red River of the North
River Mile: 462.09

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	0	55
Commercial	0	2
Public	0	0
Total	0	57

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	0	0	0	$648,000
Commercial	0	0	0	8,000
Public	0	0	0	0
Total	0	0	0	656,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 0.4-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation	906.3	895.9	902.4	904.3	907.6

Average Annual Flood Damages and Benefits

Annual Damages	$5,000
Annual Benefits of 100-Year Protection	0
Annual Benefits of 500-Year Protection	2,000

Table 19 - Economic Summary for Prairie Rose, North Dakota

Community: Prairie Rose
River: Red River of the North
River Mile: 460.40

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	0	21
Commercial	0	0
Public	0	0
Total	0	21

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	0	0	0	$217,000
Commercial	0	0	0	0
Public	0	0	0	0
Total	0	0	0	217,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 0.5-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation	905.0	894.9	901.6	903.5	907.0

Average Annual Flood Damages and Benefits

Annual Damages	$1,600
Annual Benefits of 100-Year Protection	0
Annual Benefits of 500-Year Protection	600

Table 20 - Economic Summary for Oakport Township, Minnesota

Community: Oakport Township
River: Red River of the North
River Mile: 442.63

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	18	258
Commercial	0	2
Public	0	0
Total	18	260

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	0	$62,000	$177,000	$3,620,000
Commercial	0	0	0	286,000
Public	0	0	0	0
Total	0	62,000	177,000	3,906,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 2.5-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation	894.0	887.0	894.6	896.0	898.7

Average Annual Flood Damages and Benefits

Annual Damages	$22,000
Annual Benefits of 100-Year Protection	2,000
Annual Benefits of 500-Year Protection	12,000

Table 21 - Economic Summary for Moorhead Township, Minnesota

Community: Moorhead Township
River: Red River of the North
River Mile: 456.08

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	18	29
Commercial	1	1
Public	0	0
Total	19	30

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	$105,000	$362,000	$508,000	$877,000
Commercial	0	0	1,000	2,000
Public	0	0	0	0
Total	105,000	362,000	509,000	879,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 15-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation	892.5	893.2	900.2	902.2	906.2

Average Annual Flood Damages and Benefits

Annual Damages	$34,000
Annual Benefits of 100-Year Protection	26,000
Annual Benefits of 500-Year Protection	32,000

Table 22 - Economic Summary for Barnes Township, North Dakota

Community: Barnes Township
River: Red River of the North
River Mile: 460.4

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	15	50
Commercial	2	8
Public	0	0
Total	17	58

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	$ 0	$226,000	$361,000	$1,549,000
Commercial	3,000	4,000	5,000	36,000
Public	0	0	0	0
Total	3,000	230,000	366,000	1,585,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 10-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation	895.0	895.0	901.6	903.5	907.0

Average Annual Flood Damages and Benefits

Annual Damages	$58,000
Annual Benefits of 100-Year Protection	48,000
Annual Benefits of 500-Year Protection	53,000

Table 23 - Economic Summary for Stanley Township, North Dakota

Community: Stanley Township
River: Red River of the North
River Mile: 463.3

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	93	125
Commercial	0	0
Public	1	2
Total	94	127

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	$162,000	$1,254,000	$2,307,000	$3,607,000
Commercial	0	0	0	0
Public	0	0	2,000	16,000
Total	162,000	1,254,000	2,309,000	3,623,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 15-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation	896.2	896.6	903.0	904.9	907.9

Average Annual Flood Damages and Benefits

Annual Damages	$120,000
Annual Benefits of 100-Year Protection	90,000
Annual Benefits of 500-Year Protection	110,000

o <u>Flood Insurance and Floodplain Regulation</u> - Flood insurance would supplement primarily nonstructural flood control measures by helping to reimburse the affected property owners for losses sustained from flood damages. Floodplain regulations would be used in conjunction with flood insurance to restrict future development in the floodplain. This measure does not reduce flood damages in and of itself. It does, however, afford the individual affected some economic protection from flood loss by spreading losses over a large group of persons.

Under the provisions of the regular Flood Insurance Program, eligible communities are responsible for planning, adopting, and enforcing local floodplain regulations. These regulations must minimize future flood damages and may include (1) subdivision regulations, (2) building codes, (3) zoning ordinances, and (4) sanitary regulations. In addition, local governments are encouraged to implement other floodplain management practices such as warning signs, urban redevelopment, open space programs, and public education programs. These ordinances and practices do not necessarily preclude development in the floodplain but rather guide the type and extent of future development permitted consistent with the flood potential.

Flood insurance is presently available in the study area. Information developed for this urban study will be useful and made available for the Federal Emergency Management Agency (FEMA) to update existing flood insurance studies at Fargo, North Dakota, and Moorhead, Minnesota.

o <u>Flood Proofing and Floodplain Evacuation</u> - This measure combines permanent evacuation of improvements from the lowest portions of the floodplain with flood proofing of the improvements in the remainder of the floodplain. Floodplain evacuation would consist of permanent evacuation, include acquisition of lands by purchase, removal of improvements, and relocation of the population from these areas. Flood proofing would consist of a combination of structural changes

and adjustments to properties subject to flooding primarily for reduction and elimination of flood damages. This measure may prove feasible for individual structures but is not acceptable as a solution to flooding from economic and social well-being aspects for the overall study area subject to flood damages.

Structural

Structural flood control alternatives were developed for the remaining communities to the detail needed to determine economic feasibility. Cost estimates were computed; and, based on the average annual cost and the average annual damages prevented, a benefit-cost ratio was computed. This analysis determined that of the communities considered in the final screening, only Harwood and Rivertree Park had benefits exceeding the cost of providing flood protection. Pertinent information used in the final screening process is summarized in tables 24 through 29 and discussed in the following paragraphs.

Briarwood - Briarwood is located at river mile 464.4 along the left bank of the Red River of the North. Damages were determined to begin at approximately a 20-year flood and to increase for greater flood events. The alternative developed for Briarwood would protect against floods up to and including the 1-percent exceedance frequency flood, with 3 feet of freeboard. To provide Briarwood with this level of protection would require a combination ring levee and floodwall encircling the community with necessary interior flood control facilities. A portion of the community is developed right to the bank of the river, making levees in this portion difficult, if not impossible, to construct without some channel relocation. A floodwall in this area (approximately 1,000 feet) was determined to be less costly than necessary channel relocation.

There is an existing pond of approximately 3 acres of surface area, with an undeveloped area around the pond. The total area is approximately 7 acres, including the pond. The total area protected with this plan would be approximately 55 acres. In addition to the protected area, another 425 acres outside the protected area drains through Briarwood

Table 24 - Economic Summary for Briarwood, North Dakota

Community: Briarwood
River: Red River of the North
River Mile: 464.40

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	19	20
Commercial	0	0
Public	0	0
Total	19	20

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	0	$204,000	$1,091,000	$1,916,000
Commercial	0	0	0	0
Public	0	0	0	0
Total	0	204,000	1,091,000	1,916,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 5-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation	900.1	897.6	904.2	905.9	908.8

Average Annual Flood Damages and Benefits

Annual Damages	$24,000
Annual Benefits of 100-Year Protection	12,000
Annual Benefits of 500-Year Protection	20,000

Net Benefits

Benefits	$12,000
Costs	71,000
Benefit-Cost Ratio	0.17
Net Benefits	-59,000

and into the pond created by blocking the normal flow of the ditch. Final design would require normal runoff during normal Red River conditions to flow through the line of protection. During heavy rains or blocked gravity conditions caused by high levels on the Red River, the flow from the 425 acres would be diverted to the Red River along the line of protection. A small pumping station and gravity outlet would be required to handle interior runoff. The cost of this plan as described would be $1,100,000. As presented in table 24, this plan results in average annual benefits of $12,000 compared to costs of $71,000, resulting in a benefit-cost ratio of 0.17. Federal participation for flood control at Briarwood is not economically justified.

North River - North River, North Dakota, is at river mile 437.5 along the west bank of the Red River of the North. The areas subject to flood damages are separated by County Highway 81. Damages were determined to begin at a flood having an exceedance frequency of 3 percent. About 20 homes in the area west of County Highway 81 and about 24 homes in the area east of the highway are subject to flooding. The plan developed for North River includes a levee around the area east of Highway 81 and a levee around the area west of the highway. The section of highway along the west part of the community would need to be raised to serve as the levee along the river. The total road raise would be about 2,500 feet. The highway runs right along the left bank of the river in a portion of this reach that would require several hundred feet of channel relocation because of foundation problems associated with construction of the levee along the riverbank. The homes east of the highway are constructed within 25 feet of the slope to the channel, which would make a levee in this area extremely difficult. It was assumed, however, that a levee in this reach along the slope would be possible for this stage of study.

The total cost of providing protection for these two areas of North River for floods up to and including the 1-percent exceedance frequency flood with 3 feet of freeboard as described would be $1,360,000. As presented in table 25, this plan results in average annual benefits of $11,000 compared to costs of $114,000, resulting in a benefit-cost ratio

Table 25 - Economic Summary for North River, North Dakota

Community: North River
River: Red River of the North
River Mile: 437.63

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	29	44
Commercial	0	0
Public	0	0
Total	29	44

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	0	$650,000	$734,000	$1,249,000
Commercial	0	0	0	0
Public	0	0	0	0
Total	0	650,000	734,000	1,249,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 3-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation	889.5	884.7	892.5	893.5	895.5

Average Annual Flood Damages and Benefits

Annual Damages	$21,000
Annual Benefits of 100-Year Protection	11,000
Annual Benefits of 500-Year Protection	18,000

Net Benefits

Benefits	$ 11,000
Costs	114,000
Benefit-Cost Ratio	0.10
Net Benefits	-103,000

of 0.10. Federal participation for flood control at North River is not economically justified.

<u>Reile's Acres</u> - Reile's Acres is about 2.5 miles east of the Sheyenne River and 1 mile west of Interstate Highway 29. Actual flood elevations for various frequency floods are difficult to determine because of the levee effects of the existing road systems. Profiles developed along the Sheyenne River are based on the flood-confinement effect of the road system. As the flood elevations rise, the roads become overtopped. A series of roads must be overtopped before Reile's Acres becomes threatened. In the Reile's Acres flood problem analysis, a conservative approach was taken to determine project feasibility. Under this approach, damage would begin at a flood with a 6.7-percent exceedance frequency. The plan developed would provide protection for the 50 structures in the community against floods up to and including the 1-percent exceedance frequency flood with 3 feet of freeboard. The plan consists of a levee completely encircling the community with necessary interior flood control facilities to handle interior runoff. The road along the east side of the protected area is sufficiently high so that the levee could tie into it with only minor modifications to the road. The total cost of this plan as described would be $670,000. As presented in table 26, this plan results in average annual benefits of $36,000 compared to costs of $56,000, resulting in a benefit-cost ratio of 0.64. Federal participation for flood control at Reile's Acres is not economically justified.

<u>Brooktree Park</u> - Brooktree Park is along the left bank of the Sheyenne River downstream of Interstate Highway 29. The flood elevations by flood frequency presented in table 27 refer to the Sheyenne River at the mouth of the Maple River. This information was obtained from the Sheyenne River report. The plan developed for Brooktree Park would provide protection for floods up to and including the 1-percent exceedance frequency flood with 3 feet of freeboard. To provide Brooktree Park with this level of protection would require a levee encircling the community, 1,200 feet of channel relocation, and necessary interior flood control facilities. Because a portion of the

Table 26 - Economic Summary for Reile's Acres, North Dakota

Community: Reile's Acres
River: Sheyenne River

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	49	49
Commercial	0	0
Public	1	1
Total	50	50

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2 Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	0	$1,240,000	$1,662,000	$1,848,000
Commercial	0	0	0	0
Public	0	0	0	1,000
Total	0	1,240,000	1,662,000	1,849,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 6-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation	888.0	886.1	891.0	892.0	893.0

Average Annual Flood Damages and Benefits

Annual Damages	$53,000
Annual Benefits of 100-Year Protection	36,000
Annual Benefits of 500-Year Protection	49,000

Net Benefits

Benefits	$36,000
Costs	56,000
Benefit-Cost Ratio	0.64
Net Benefits	-20,000

Table 27 - Economic Summary for Brooktree Park, North Dakota

Community: Brooktree Park
River: Sheyenne River

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	31	34
Commercial	0	0
Public	0	0
Total	31	34

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	$252,000	$692,000	$755,000	$843,000
Commercial	0	0	0	0
Public	0	0	0	0
Total	252,000	692,000	755,000	843,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 33-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation*	890.0	894.0	898.0	900.4	903.3

* Elevation relates to the elevation frequency curve at the mouth of the Maple River (see plate 20).

Average Annual Flood Damages and Benefits

Annual Damages	$73,000
Annual Benefits of 100-Year Protection	61,000
Annual Benefits of 500-Year Protection	66,000

Net Benefits

Benefits	$61,000
Costs	94,000
Benefit-Cost Ratio	0.65
Net Benefits	-33,000

Study Cost Estimate - Table 35 presents study cost estimates for a reconnaissance study and a detailed project study. The reconnaissance study would examine the plan identified at Harwood in sufficient detail to enable the selection of a final alternative. The detailed project study would resolve all technical problems of the selected alternative so that the project would be ready for final plans and specifications.

Table 35 - Costs for Additional Studies, Harwood

	Reconnaissance Study	Detailed Project Study
Preliminary Planning and Public Contacts	$ 5,000	$ 10,000
Hydrology and Hydraulic Studies	10,000	20,000
Surveys, Mapping, and Foundation Design	15,000	20,000
Design and Cost Estimates	2,000	30,000
Environmental and Cultural Studies	3,000	6,000
Socioeconomic Studies	12,000	10,000
Real Estate	2,000	3,000
Fish and Wildlife Service Participation	1,000	3,000
Report Preparation	5,000	8,000
Supervision and Administration	5,000	8,000
Total Study Cost	60,000	118,000

RECOMMENDATIONS

Based on the results of the flood control investigations, I recommend that:

- The communities of Harwood and Rivertree Park, North Dakota, consider requesting that the Corps of Engineers conduct detailed studies of flood damage reduction measures.

- All communities in the study area adopt/enforce sound floodplain management practices that would minimize future flood damages.

Table 34 - Preliminary Cost Estimate, Selected Plan at Harwood

Item	Units	Amount	Unit Price	Total Cost
Ponding Area				
Stripping	C.Y.	3,200	1.50	$ 4,800
Excavation	C.Y.	32,000	1.80	57,600
Topsoiling	C.Y.	3,200	1.75	5,600
Seeding	Acres	4	800	3,200
Borrow Area				
Stripping and Replacing	L.S.			5,000
Levee				
Stripping	C.Y.	8,200	1.80	14,800
Inspection Trench	L.F.	11,000	5.00	55,000
Embankment Fill	C.Y.	50,000	4.00	200,000
Topsoiling	C.Y.	8,200	2.00	16,400
Seeding	Acres	15	800	12,000
Road Ramps	L.S.			36,000
Discharge Ditch	L.S.			12,000
Interior Drainage	L.S.			300,000
Contingencies				144,630
Estimated Construction Cost				867,000
Engineering and Design				139,000
Supervision and Administration				69,000
Real Estate Requirements				125,000
Total Project Estimate				1,300,000

Environmental Considerations - The immediate impact area offers relatively little in the way of wildlife habitat. The land use is entirely residential and agricultural. Vegetation consists of cultivated crops and residential trees, shrubs, and grass. Wildlife use would include squirrels, song birds, Hungarian partridge, and other species utilizing residential areas and roadsides.

It appears that the levees at Harwood would cause very little impact. The levees would either consist of road raises or earth levees in agricultural fields. Some roadside ditches could be lost but it is unlikely that any woodlands or wetland vegetation would be affected.

A detailed evaluation and environmental assessment, including an evaluation of the parameters discussed in Section 122 of the 1970 Rivers and Harbors Act, would be prepared in future studies. Documentation required by the National Environmental Policy Act, Clean Water Act, Fish and Wildlife Coordination Act, and Endangered Species Act would also be prepared at that time. The U.S. Fish and Wildlife Service has been contacted concerning the potential project at Harwood, and their concerns have been incorporated. A copy of their planning aid letter dated February 20, 1985, is included at the end of this report.

Cultural Resources Considerations - The discussion on cultural resources for Harwood was included in the Rivertree Park discussion on page 66.

Economic Analysis - As summarized in table 33, the plan identified for flood control at Harwood results in a benefit-cost ratio of 3.3. The analysis performed and the results presented in this report indicate that there is good potential for an economically feasible and environmentally acceptable plan and that more detailed studies are warranted under the Corps of Engineers Section 205 authority.

Project Cost Estimate - A preliminary cost estimate was made for the selected plan at Harwood (see table 34).

Table 33 - Economic Summary for Harwood, North Dakota

Community: Harwood
River: Sheyenne River

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	75	87
Commercial	5	6
Public	1	2
Total	81	95

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	$1,653,000	$2,430,000	$2,700,000	$3,230,000
Commercial	75,000	105,000	396,000	472,000
Public	2,000	2,000	4,000	16,000
Total	1,730,000	2,537,000	3,100,000	3,718,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 30-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation*	890.0	894.0	898.0	900.4	903.3

* Elevation relates to the elevation frequency curve at the mouth of the Maple River (see plate 20).

Average Annual Flood Damages and Benefits

Annual Damages	$404,000
Annual Benefits of 100-Year Protection	332,000
Annual Benefits of 500-Year Protection	363,000

Net Benefits

Benefits	$332,000
Costs	100,000
Benefit-Cost Ratio	3.3
Net Benefits	232,000

Study Cost Estimate - Table 32 presents study cost estimates for a reconnaissance and a detailed project study. The reconnaissance study would examine the plan identified at Rivertree Park in sufficient detail to enable the selection of a final alternative. The detailed project study would resolve all technical problems of the selected alternative so that the project would be ready for final plans and specifications.

Table 32 - Costs for Additional Studies, Rivertree Park

	Reconnaissance Study	Detailed Project Study
Preliminary Planning and Public Contacts	$ 5,000	$ 10,000
Hydrology and Hydraulic Studies	10,000	20,000
Surveys, Mapping, and Foundation Design	15,000	20,000
Design and Cost Estimates	2,000	30,000
Environmental and Cultural Studies	3,000	6,000
Socioeconomic Studies	12,000	10,000
Real Estate	2,000	3,000
Fish and Wildlife Service Participation	1,000	3,000
Report Preparation	5,000	8,000
Supervision and Administration	5,000	8,000
Total Study Cost	60,000	118,000

Harwood

Pertinent information for Harwood is summarized in table 33. The plan selected at Harwood (plate 11) consists of levees, road ramps, and interior flood control facilities. The levee would have a total length of approximately 11,000 feet and would basically encircle the entire community. Two road ramps would be needed where the levee crosses existing roads as shown on plate 11. Interior flood control facilities would be required consisting of an excavated ponding area, gravity outlet, small pumping station, and interior ditches and necessary culverts to convey the interior runoff to the ponding area. A discharge ditch would be needed to convey the interior runoff from the outlet to an existing coulee leading to the Red River of the North.

environmentally acceptable plan and that more detailed studies are warranted under the Corps of Engineers Section 205 authority.

Project Cost Estimate - A preliminary cost estimate was made for the selected plan at Rivertree Park (see table 31).

Table 31 - Preliminary Cost Estimate, Selected Plan, Rivertree Park

Item	Units	Amount	Unit Price	Total Cost
Excavation Material	C.Y.	24,600	2.50	$ 61,500
Channel Fill	C.Y.	24,600	1.00	24,600
Embankment Fill	C.Y.	57,800	2.00	115,600
Stripping				
(Side Bank and Levee)	C.Y.	200	1.80	360
Clearing and Grubbing	Acres	5	1,500	7,500
Ponding Area				
Stripping	C.Y.	1,800	1.50	2,700
Excavation	C.Y.	18,000	1.80	32,400
Topsoiling	C.Y.	1,800	1.75	3,150
Seeding	Acres	2.25	800	1,800
Levee				
Stripping	C.Y.	6,000	1.80	10,800
Inspection Trench	L.F.	6,600	5.00	33,000
Embankment Fill	C.Y.	36,000	4.50	162,000
Topsoiling	C.Y.	6,000	2.00	12,000
Seeding	Acres	12	800	9,600
Borrow Area				
Stripping and Replacing	L.S.			9,000
Road Raises and Ramps				
Fill	C.Y.	3,600	5.00	18,000
Pavement Removal	L.S.			2,000
Pavement	L.S.			50,000
Topsoil	C.Y.	120	4.00	360
Seeding	L.S.			500
Interior Flood Control	L.S.			250,000
Contingencies				161,130
Estimated Construction Cost				968,000
Engineering and Design				155,000
Supervision and Administration				77,000
Real Estate Requirements				100,000
Total Project Estimate				1,300,000

concerns have been incorporated. A copy of their planning aid letter dated February 20, 1985, is included at the end of this report.

Cultural Resources Considerations - A cultural resources reconnaissance of the Rivertree Park and Harwood communities was conducted by the Corps of Engineers in 1977 as part of the Sheyenne River study. A site (32-CS-205) was located in the vicinity of Harwood. The site is an open site of Woodland affiliation. Ceramic material located at this site is similar to Sandy Lake Ware from northcentral Minnesota, which places the site in a Late Woodland context dating to 1000-300 B.P. (before present).

A cultural resources records check was made in December 1984 with the North Dakota Historic Preservation Office. Two additional sites have also been recorded within the State's site files: the Harwood townsite and a school noted on an 1884 atlas. Both of these historic sites are in the immediate vicinity of present-day Harwood and Rivertree Park.

In accordance with Section 106 of the National Historic Preservation Act of 1966, as amended, the National Register of Historic Places has been consulted. As of November 22, 1984, no properties listed on or determined eligible for the National Register will be affected by the proposed levees at Rivertree Park and Harwood.

The three sites within the Rivertree Park and Harwood areas may be affected by construction of flood control alternatives. Further studies for flood control at these locations should include a survey for archeological and historic resources. A preliminary architectural survey should be conducted to determine whether there are extant structures such as the Harwood townsite and the old school.

Economic Analysis - As summarized in table 30, the plan identified for flood control at Rivertree Park results in a benefit-cost ratio of 1.63. The analysis performed and the results presented in this report indicate that there is good potential for an economically feasible and

beaver, deer, raccoon, squirrel, hawks, and other species. The Sheyenne River itself provides local fishing and canoeing opportunities. During wet portions of the year, there may be temporary wetlands in some agricultural fields.

The impacts of a local flood control project at Rivertree Park would be greater than at Harwood, but still would not be significant. Although portions of the levee would be placed in agricultural lands, up to 8 acres of floodplain/residential woodland could be lost, depending on final levee alignment. It appears that a temporary wetland north of the subdivision could be avoided.

The project also involves about 800 feet of channel work consisting of channel relocation and embankment fill on the right bank. This work is necessary because residential development is very close to the riverbank. The disruption of the floodplain forest and loss of vegetation would affect terrestrial and aquatic values and aesthetic qualities. Because woodlands are an important resource in this portion of North Dakota, their loss should be minimized as much as possible.

To minimize or mitigate environmental losses, certain features should be included with the project: (1) the bottom width of the new channel should be the same size as the natural channel in this area so that fish passage would not be impeded during low flow; (2) where appropriate, the levee should be reseeded with native grasses to provide nesting habitat; and (3) the loss of floodplain woodlands should be mitigated by replanting at a rate of 2 for 1.

A detailed evaluation and environmental assessment, including an evaluation of the parameters discussed in Section 122 of the 1970 Rivers and Harbors Act, would be prepared under future studies. Documentation required by the National Environmental Policy Act, Clean Water Act, Fish and Wildlife Coordination Act, and Endangered Species Act would also be prepared at that time. The U.S. Fish and Wildlife Service has been contacted concerning the potential project at Rivertree Park, and their

Table 30 - Economic Summary for Rivertree Park, North Dakota

Community: Rivertree Park
River: Sheyenne River

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	60	61
Commercial	0	0
Public	0	0
Total	60	61

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	$650,000	$1,430,000	$1,500,000	$1,670,000
Commercial	0	0	0	0
Public	0	0	0	0
Total	650,000	1,430,000	1,500,000	1,670,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 30-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation*	890.0	894.0	898.0	900.4	903.3

* Elevation relates to the elevation frequency curve at the mouth of the Maple River (see plate 20).

Average Annual Flood Damages and Benefits

Annual Damages	$212,000
Annual Benefits of 100-Year Protection	178,000
Annual Benefits of 500-Year Protection	190,000

Net Benefits

Benefits	$178,000
Costs	109,000
Benefit-Cost Ratio	1.63
Net Benefits	69,000

River and the Red River of the North. Flooding at Harwood is influenced by conditions on the Sheyenne River and the Red River of the North.

PLANS SELECTED

An alternative plan was developed for each of the two communities that would provide protection for floods up to and including the 1-percent exceedance frequency flood. A higher level of protection may be recommended during more detailed studies that could be performed under the Section 205 authority.

Rivertree Park

Pertinent information for Rivertree Park is summarized in table 30. The plan selected at Rivertree Park (see plate 11) consists of levees, a road raise, channel relocation, and interior flood control facilities. The levee would have a total length of approximately 6,600 feet around the west, north, and east sides f the community. County Road 22 along the south side of Rivertree Park would be raised for a total length of about 700 feet that would serve as a flood barrier. Development just north of County Road 22 has occurred along the right bank of the river. Because of foundation problems associated with construction of a levee or floodwall in this reach, channel relocation would be needed. The modifications would consist of approximately 800 feet of channel relocations starting at the bridge and embankment fill for the same distance along the right bank to provide the necessary room for a levee.

Interior flood control facilities would be required. These facilities consist of an excavated ponding area, a gravity outlet, a small pumping station, and interior ditches and culverts.

Environmental Considerations - Land use in this area consists of the natural floodplain forest along the Sheyenne River, residential areas, and cultivated cropland. The floodplain forest is very valuable in this area because it represents a large portion of the wildlife habitat in an area that is about 90 percent agricultural. Wildlife use includes

- The flooding in these communities occurs in a long narrow strip along the river. This damage strip measured from north to south is approximately 7 miles for Fargo and 5 miles for Moorhead. The actual river miles are much greater. Protection would therefore require extremely long levees and/or floodwalls at high cost.

- The area is relatively flat and does not provide high ground to tie into. Therefore protection from larger floods would require the entire urban area to be more or less ringed by a combination of levees, floodwalls, and road raises.

- Major developments occur up to the banks of the river, making levee placement extremely difficult. Foundation problems associated with placement of levees along the riverbank would require costly relocations of structures to allow for necessary setback for the levees, floodwalls, and possible channel modifications.

Because the costs of providing necessary flood protection at Fargo and Moorhead would greatly exceed the damages prevented, Federal participation in flood control is not economically justified.

PROJECTS THAT DEMONSTRATE ECONOMIC FEASIBILITY

Flood protection for the communities of Rivertree Park and Harwood showed benefit-cost ratios greater than 1.0 (benefits derived from construction of a project exceed the cost). Because construction costs are relatively low, additional more detailed studies may be conducted under the Corps of Engineers Section 205 Small Project Program, which provides a quicker process to construction than other Corps of Engineers programs.

Rivertree Park is between the Sheyenne River and Interstate 29 and is subject to recurring flooding from the Sheyenne River. The backwater effect from the Red River of the North influences the levels along the Sheyenne River at Rivertree Park. Harwood is east of Rivertree Park on the east side of Interstate 29 within the floodplain of the Sheyenne

Table 29 - Economic Summary for Moorhead, Minnesota

Community: Moorhead
River: Red River of the North
River Mile: 452.92

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	244	673
Commercial	5	9
Public	5	5
Total	254	687

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	$4,000	$2,555,000	$4,845,000	$13,754,000
Commercial	0	40,000	72,000	100,000
Public	2,000	2,000	3,000	3,000
Total	6,000	2,597,000	4,920,000	13,857,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 12-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation	891.5	891.7	899.0	901.0	905.2

Average Annual Flood Damages and Benefits

Annual Damages	$264,000
Annual Benefits of 100-Year Protection	144,000
Annual Benefits of 500-Year Protection	238,000

Table 28 - Economic Summary for Fargo, North Dakota

Community: Fargo
River: Red River of the North
River Mile: 452.92

Number of Structures in the Floodplain

Type of Structure	100-Year Floodplain	500-Year Floodplain
Residential	494	2,840
Commercial	11	19
Public	10	12
Total	515	2,871

Flood Damages by Frequency

Exceedance Frequency (Return Period)	10-Percent (10-Year)	2-Percent (50-Year)	1-Percent (100-Year)	0.2-Percent (500-Year)
Residential	$202,000	$3,980,000	$9,171,000	$93,009,000
Commercial	10,000	26,000	57,000	80,000
Public	0	2,000	6,000	24,000
Total	212,000	4,008,000	9,234,000	93,113,000

Flood Elevations by Frequency

Exceedance Frequency	(Zero Damage) 20-Percent	10-Percent	2-Percent	1-Percent	0.2-Percent
Elevation	888.0	891.7	899.0	901.0	905.2

Average Annual Flood Damages and Benefits

Annual Damages	$700,000
Annual Benefits of 100-Year Protection	240,000
Annual Benefits of 500-Year Protection	550,000

community is developed right on the bank of the slope to the river, channel relocation is necessary to allow a line of protection between the community and the river. The cost of this plan as described would be $1,100,000. As presented in table 27, this plan results in average annual benefits of $61,000 compared to costs of $94,000, resulting in a benefit-cost ratio of 0.65. A second alternative was developed that assumed a floodwall could be constructed along portions of the river, thereby eliminating the channel relocation. The cost of this plan would be $911,000, with a benefit-cost ratio of 0.80. Federal participation for flood control at Brooktree Park is not economically justified.

Fargo-Moorhead - Damage calculations for Fargo and Moorhead were divided into 13 and 5 reaches, respectively. This division was done because flooding to these communities occurs in a long narrow strip along the river in which individualized protection might be possible. The information provided in tables 28 and 29 for Fargo and Moorhead, respectively, is presented in combined form.

As summarized in the tables, major damages occur for the more infrequent floods. When these damages are amortized on an annual basis, the annual damages at Fargo and Moorhead would be $700,000 and $264,000, respectively. Providing 1-percent exceedance frequency flood protection would result in annual benefits of $350,000 at Fargo and $144,000 at Moorhead. In order to have an economically feasible project, the maximum allowable project costs could be $2,900,000 at Fargo and $1,700,000 at Moorhead, assuming an interest rate of 8-3/8 percent and October 1984 price levels. The amortization factor for this interest rate and a project life of 100 years is 0.08378.

Because of the following reasons, feasible alternatives could not be identified for Fargo and Moorhead:

- The floodplain in the Fargo-Moorhead urban reach is very constricted and damages are relatively limited except for extremely infrequent events that overtop the secondary bank; thus, damages on an annual basis are not that great.

- Hydrologic, hydraulic, and topographic information developed during the study be used by the Federal Emergency Management Agency (FEMA) to update existing flood insurance studies for Fargo and Moorhead to include a revised floodway through the urban area.

- Hydrologic, hydraulic, and topographic information developed during the urban study be used by local communities (with assistance from appropriate county, State, and Federal agencies) for purposes such as preparing emergency flood fight plans, designing bridges, and determining in-stream storage for water supply/conservation.

Edward G. Rapp

Edward G. Rapp
Colonel, Corps of Engineers
District Engineer

FISH AND WILDLIFE SERVICE

PLANNING AID LETTER

United States Department of the Interior
FISH AND WILDLIFE SERVICE
1500 CAPITOL AVENUE
BISMARCK, NORTH DAKOTA 58501

FEB 2 0 1985

Colonel Edward G. Rapp, District Engineer
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

This planning aid letter provides our preliminary views on the levee study for the communities of Rivertree Park and Harwood. The study has evolved from the Fargo-Moorhead Urban Water Resources Study.

Our comments provide technical assistance to aid the Corps in the development of a study plan. Our comments do not constitute the report of the Secretary of the Interior pursuant to Section 2(b) of the Fish and Wildlife Coordination Act, nor do they represent the review comments of the Department of the Interior on any forthcoming environmental statement.

Rivertree Park and Harwood are located in eastern Cass County (Figure 1), immediately on the east side of the Sheyenne River and 1 1/4 miles upstream from the confluence with the Rush River. About 2 1/2 miles to the east is the Red River of the North. The two communities are apparently vulnerable to flooding from the overtopping of these rivers and their tributaries. This can be caused by a number of variables which include snowmelt, rainfall, wetland drainage and intensive land-use practices.

The Red River has a 20 to 50-foot wide channel that winds through the lake plain of the extinct glacial Lake Agassiz. North Dakota's part of the lake plain is about 35 miles wide. Recorded flows for the Red River near Rivertree Park and Harwood average 554 cfs or 401,400 acre-feet per year with a recorded peak discharge over 25,000 cfs, or about 50,000 acre-feet in 1 day.

The Rush River empties into the Sheyenne River about 6 miles before the latter's confluence with the northward flowing Red River. Recorded flows for the Rush River near Amenia average 9.07 cfs or 6,570 acre-feet per year with a recorded peak discharge of 3,490 or 6,920 acre-feet in 1 day. Flows in the Sheyenne River at West Fargo average 172 cfs or 125,600 acre-feet per year with a recorded peak discharge of 3,480 cfs or 6,900 acre-feet in 1 day.

A combined population of 441 people live in Rivertree Park and Harwood. About 5 miles to the south is the combined Fargo and West Fargo urban population of 71,407. This accounts for more than 70 percent of the total Cass County population.

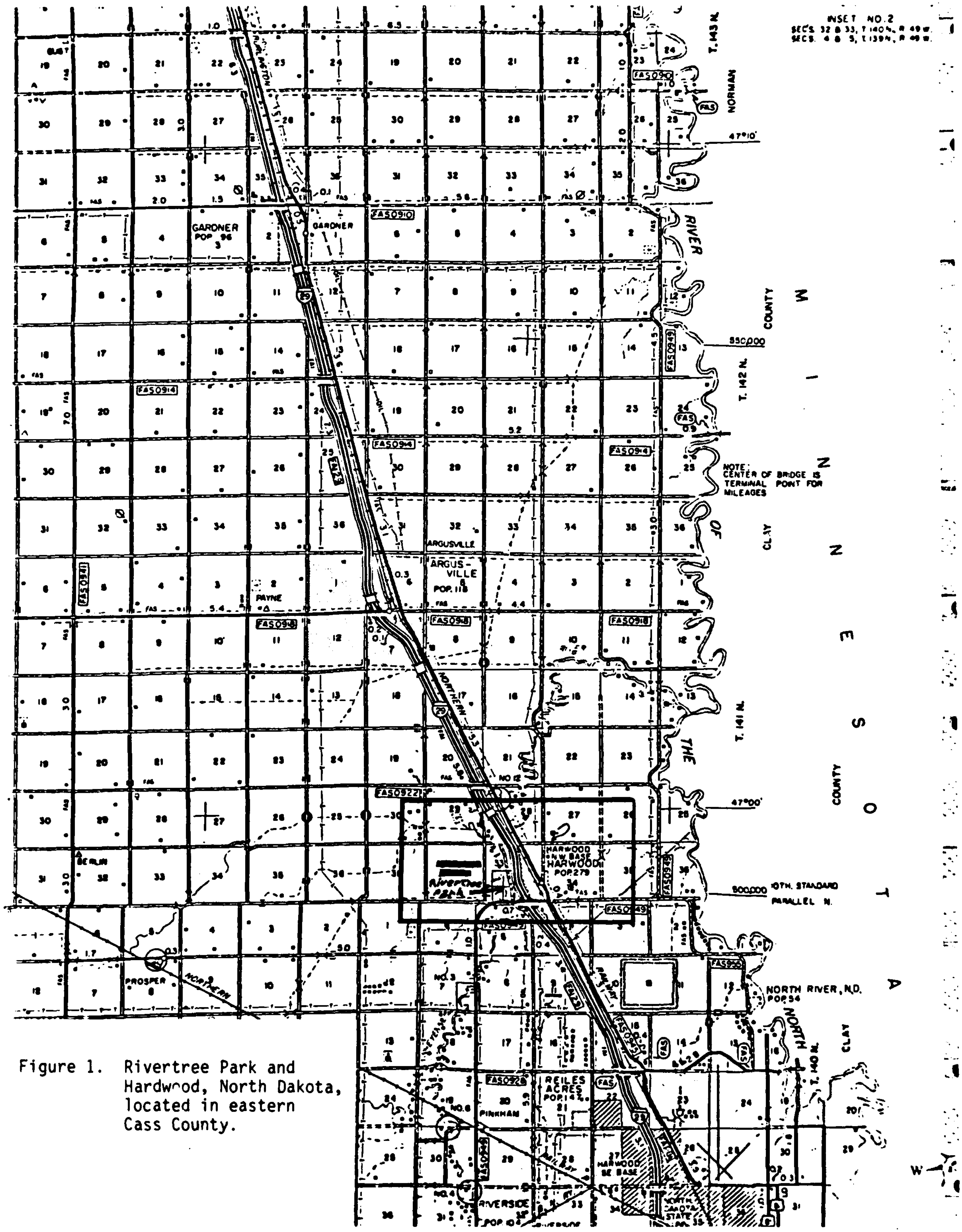


Figure 1. Rivertree Park and Hardwood, North Dakota, located in eastern Cass County.

The climate in the area of the two communities is a subhumid to humid continental type with relatively warm summers and cold winters. Temperatures may range from -40° F to 104° F. The mean length of the freeze-free period is 132 days. Annual mean precipitation is 20.78 inches.

The soil of the area is Fargo clay locally known as gumbo. Crops best grown in the soil include wheat, barley, flax, rye, alfalfa, sweet clover and corn. Potatoes do fairly well on the better-drained areas, especially in rather dry years.

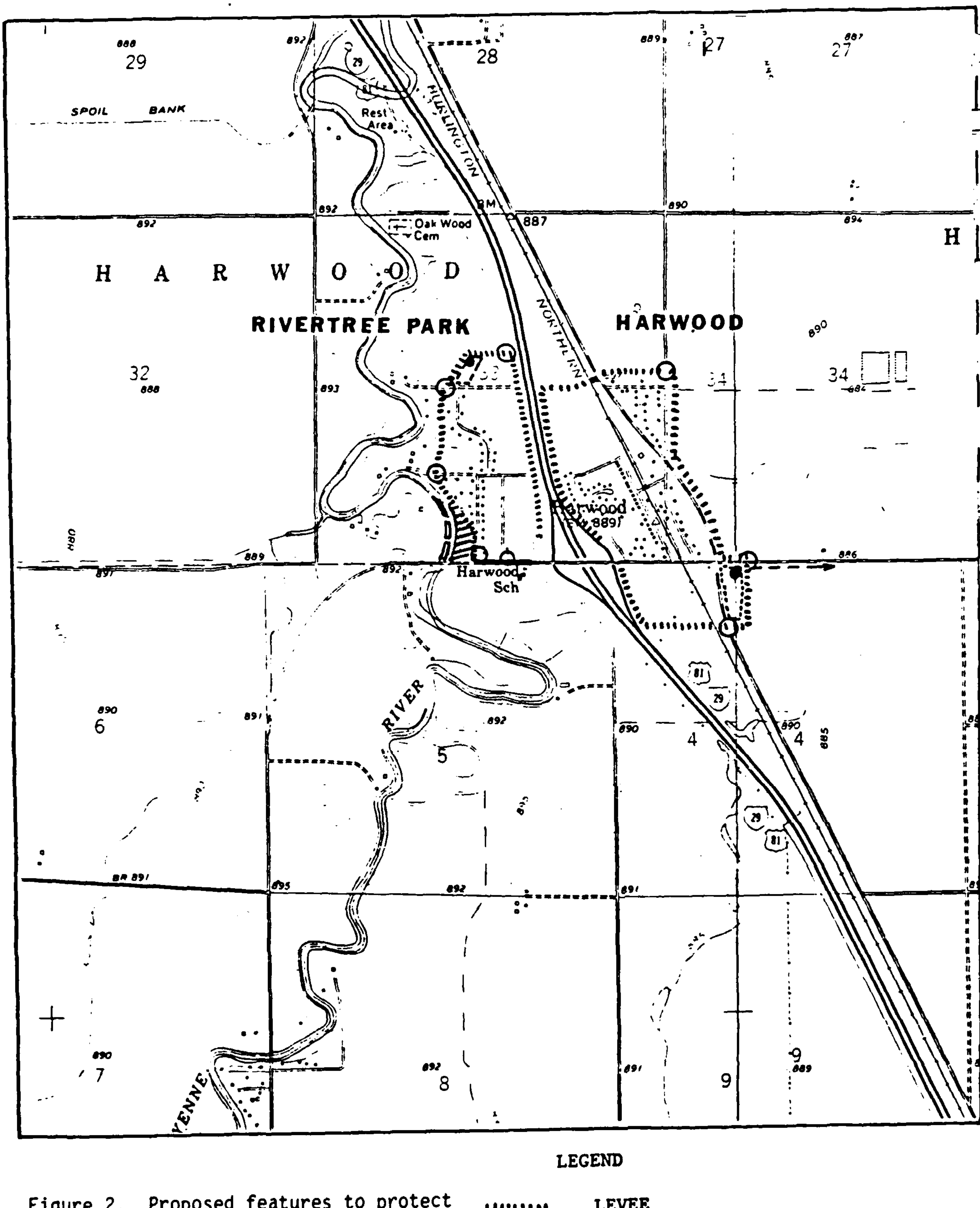
Much of the flat lake plain near the two communities was historically predominated by wetlands having shallow water regimes. The surfaces of many wetlands seldom held water but were saturated throughout their substrate. Other commonly occurring wetlands were seasonally and semipermanently flooded. For many years wetland drainage has increased the amount of land in cultivation in the lake plain. This trend has nearly ceased since most of the land in the lake plain is now drained and being used for agricultural purposes.

Our analysis of the study area was aided by aerial imagery and a map and description of the project features provided by members of your staff in the St. Paul District. Figure 2 depicts the project features and Table 1 describes the proposed levees and channel work.

Table 1. Proposed channel work in the Sheyenne River and levees around Rivertree Park and Harwood.

Community	Channel Work (feet)	Levee Length (feet)	Bottom Width (feet)	Area (acres)
Rivertree Park	800	6,600	50	7.6
Harwood	---	11,000	50	12.6

A description of the <u>fish and wildlife resources</u> in the study area was provided to the Corps in our letter of October 12, 1983. This includes our discussion of the two Federally listed <u>threatened and endangered species</u> that may occasionally be found within the study area. They are the bald eagle and peregrine falcon. This was followed by an evaluation of the study area's various cover types using the "U.S. Fish and Wildlife Service's Mitigation Policy" (<u>Federal Register</u>; January 23, 1981).



LEGEND

Figure 2. Proposed features to protect the communities of Rivertree Park and Harwood against flooding.

LEVEE
CHANNEL RELOCATION
EMBANKMENT FILL
PONDING AREA
PUMPING STATION
ROAD RAMP
ROAD RAISE

Table 2 outlines the cover types of the total 203 acres inside the boundaries of the proposed levees. An 8-acre, semipermanently flooded, oxbow wetland lies just outside the northwest tip of the Rivertree Park levee. Southwest of the levee, 800 feet or about 3 acres of the Sheyenne River channel will be relocated.

Table 2. Acreage of cover types in the area of the proposed project features.

Study Area	Urban and Built-up Land	Native Woodland	Cropland	Tame/Pasture Hayland
Rivertree Park	35	8	20	25
Harwood	50	-	30	35
Total Acres	85	8	50	60

PROBLEMS AND NEEDS

Fish

The Rush River and Red River of the North are not expected to be directly impacted by project plans for the study area; nevertheless, they do have problems and needs that local, State and/or Federal interests will eventually have to address. Channel work and levee construction around Rivertree Park are the obvious direct impacts to the Sheyenne River.

Major sources of industrial pollution in the Red River are food processors: sugar beet refineries, potato processors, poultry and meat packers, and milk, cream and cheese processors. The major waste treatment problems are those of the sugar beet and potato processors. These wastes are produced seasonally at times of low stream flow and low biological activity caused by winter. Sugar wastes that reach the river at times of low flow will cause concentrations of pollutants and a reduction in dissolved oxygen.

Nonpoint sources of pollution come mainly from agriculture. Runoff from farmlands and livestock feedlots add high nutrient levels of orthophosphates, ammonia, nitrite and nitrate nitrogen. These additional nutrients cause a heavy organic content and contribute to possible stagnation during low flow. The resultant oxygen depletion could be fatal to desirable fish species and other aquatic life.

Water quality in the Rush River has been seriously degraded by agricultural runoff and intermittent flows. Dissolved oxygen concentrations are depleted during low flow periods. Streambank clearing and channelization in much of the river has reduced the productivity of its aquatic habitat.

Low flows, municipal and industrial effluent, and agricultural runoff degrade the water quality of the Sheyenne River and impair fish propagation. The Sheyenne normally has insufficient flows during late summer and fall to meet the minimum requirements for aquatic life. Low flow periods reduce the river's capacity to assimilate wastes. At this time municipal effluent and feedlot runoff can cause serious bacterial pollution. Combination of the two situations produces low dissolved oxygen concentrations in the river.

Information on the water quality in the three rivers near Rivertree Park and Hardwood needs to be updated. This would aid in identifying pollutants that limit or threaten fish resources. Ways to correct water quality problems that are harming aquatic life could then be studied and, if feasible, acted on.

The control of nutrients in runoff entering all three rivers would require changes in the land-use practices of upstream watersheds. Applications of fertilizers on lands adjacent to the rivers are a source of high nutrient levels picked up in runoff flows entering the rivers.

Water and wind erosion of farmland has caused sedimentation problems in the rivers. Turbidity levels are unacceptable in many reaches of the rivers. Bottom substrates have been silted over, reducing the productivity of habitat and the species composition of aquatic life. Land treatment measures need to be implemented that would help retain soil and water on the land and retard runoff and silt deposition into the rivers.

Wildlife

The clearing of trees, intensive drainage of wetlands and the conversion of woodlands, grasslands and other wetlands to other land uses have significantly reduced these habitat types. The effect has been detrimental on wildlife resources and decreased both the population densities and species diversity in the study area.

Narrow strips of trees and shrubs along the Sheyenne River, the Red River and their tributaries essentially provide the only remaining habitat suitable for wildlife. Agricultural and urban encroachment into many places of these green corridors have caused the removal of riparian plants almost to the water's edge.

Continual destruction and degradation of remaining habitat will result in the eventual elimination of the basic life requirements necessary for wildlife survival. As such, woodland, grassland and wetland areas have significant wildlife values that can be reestablished, restored or enhanced within the study area.

DATA DEFICIENCIES AND NEEDED STUDIES

These have been identified in Fiscal Year 1984 in our comments on your Phase I report of the Fargo-Moorhead Urban Water Resources Study.

PLAN FORMULATION

A combination of nonstructural and structural measures need to be considered to resolve the urban flooding problems in the Fargo-Moorhead study area. Structural measures may prove the quickest solution to a flooding problem but do not address such flood enhancement causes as wetland drainage, channelization and the removal of riparian habitat. We, therefore, encourage the following measures to help reduce flooding problems for such communities as Rivertree Park and Hardwood:

- Establish buffer areas and curtail residential, commercial or other development in flood plains.

- Maintain existing riparian vegetation along streams to preserve existing wildlife habitat, help control wind and streambank erosion, retain the soil on the land, and reduce the amount of sediment, nutrients and other pollutants from entering waterways.

- Maintain grassed waterways and eliminate stream channelization practices (straightening, deepening or widening) which provide only localized flood protection while moving floodwaters downstream for other areas to contend with.

- Establish vegetation windbreaks adjacent to streams (greenbelts) and in other appropriate areas to reduce erosion and help to retain the soil on the land.

- Determine the feasibility of installing water control structures on existing culverts so that water can be retained in existing drainage ditches for a longer period of time during critical runoff periods to minimize flooding in downstream areas.

- Determine the feasibility of "on-farm storage" where runoff would be controlled on each section of land by utilizing natural storage areas, culvert sizing or placing control structures on existing culverts.

- Determine the feasibility of enhancing existing, restoring previously drained or creating new wetland areas to retain as much water on the land as possible and reduce the amount of sediment and pollutants entering waterways.

- Apply more cover crops and utilize minimum tillage practices to reduce erosion, reduce the rate of snowmelt and increase subsurface moisture.

- Provide incentives to local landowners who are adjacent to tributary streams within the study area so that sound land-use practices will be implemented.

- Provide for strict enforcement of local flood-plain management programs.

If a levee system is deemed absolutely necessary for Rivertree Park and Harwood, the following considerations should be given for the protection and enhancement of fish and wildlife resources:

- The bottom width of the proposed channel should be the same size and general configuration of the natural channel that it would replace. This would avoid impeding fish passage during low flows.

- Construction activities in the Sheyenne River should be avoided from mid-March to June 1. This is a 10-week period which coincides with game and forage fish spawning activities.

- Wildlife ponds and nesting islands designed into the interior drainage plan for ponding areas would increase wildlife habitat values.

- Dense vegetative cover on cropland and/or odd areas in and near the study area would complement duck and other bird nesting requirements.

- The revegetation of levees and ponding area embankments with native and tame grasses would help prevent erosion and establish wildlife cover.

- Delaying the mowing of established wildlife vegetative cover until August 1 of each year avoids conflicts with bird nesting.

- Any project-caused loss of native woodland should be compensated by woody plantings at a rate of 2 acres for every acre lost. This would be consistent with the policy of the ND Game and Fish Department.

- Wildlife diversity would be enhanced with the establishment of new shelterbelts or field belts and the renovation of deteriorating belts.

- The Fish and Wildlife Service should be involved at the earliest possible time where there is a need for a Department of the Army permit for project development.

We appreciate the early opportunity to comment on fish and wildlife resources in and near the Rivertree Park and Harwood study areas. We would be pleased to offer our assistance in developing designs for any of the wildlife enhancement features previously discussed. If you have any questions or comments, please contact Al Ludden of my staff at FTS: 783-4485.

Sincerely,

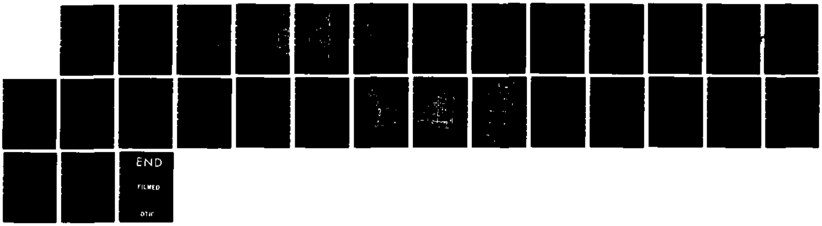
M.S. Zschomler

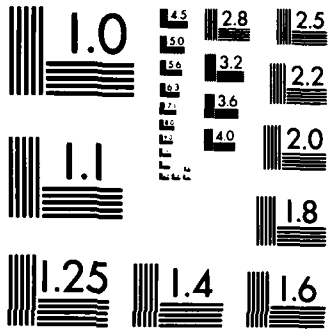
M.S. Zschomler
Field Supervisor-Habitat Resources

PLATES

AD-A157 288 FARGO-MOORHEAD URBAN STUDY FLOOD CONTROL APPENDIX(U) 2/2
CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT MAY 85

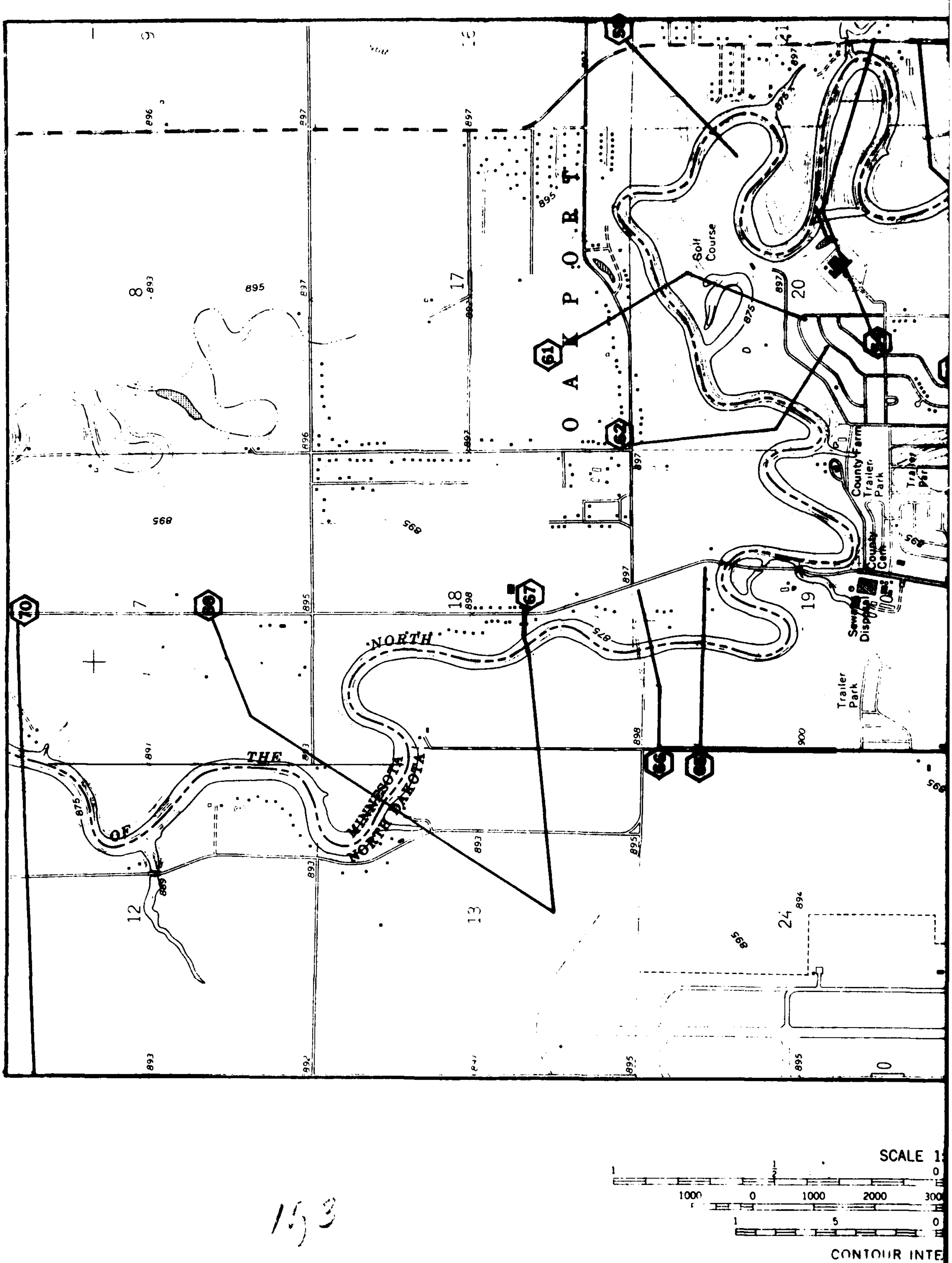
UNCLASSIFIED F/G 13/2 NL





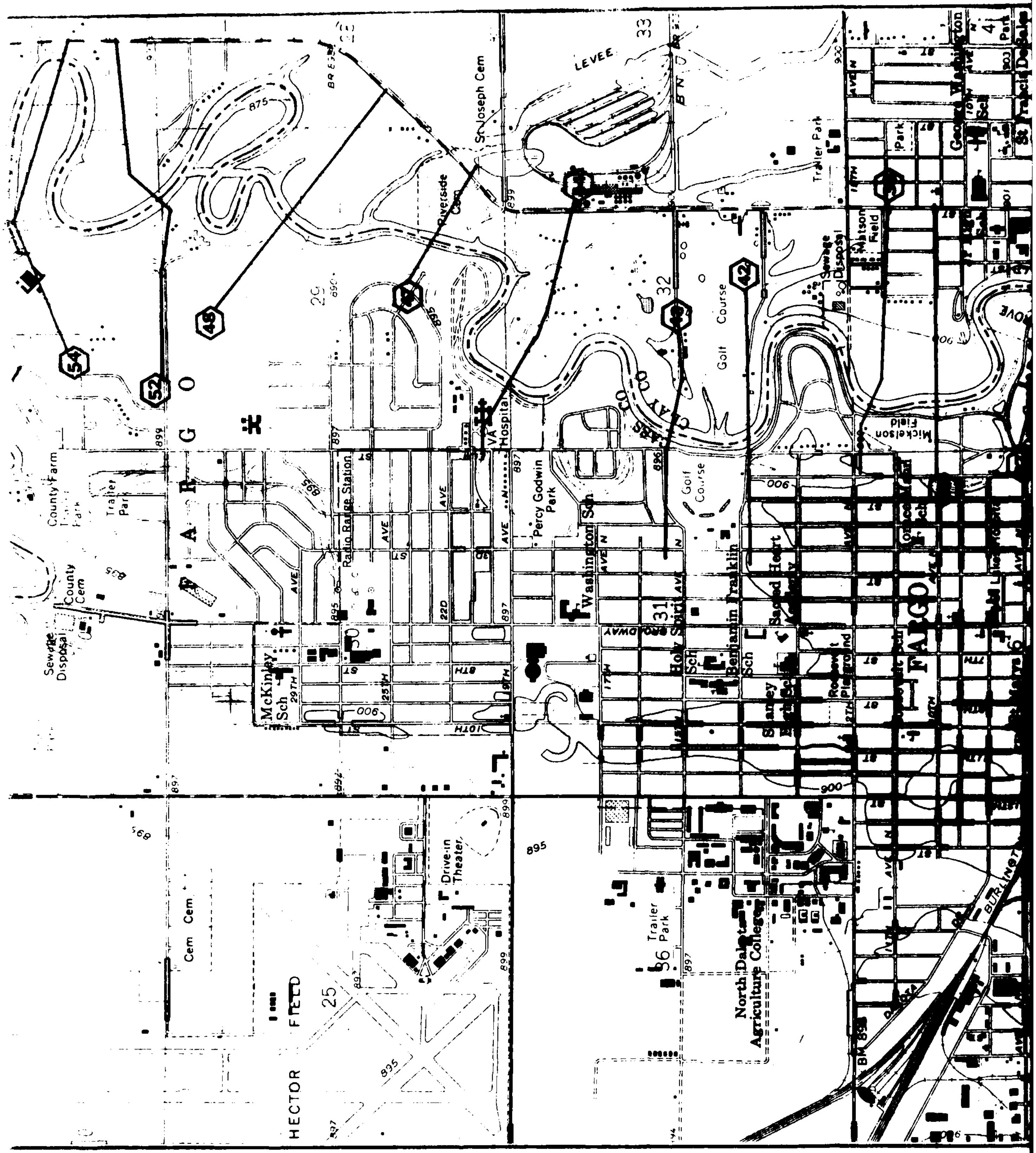
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963 A

PLATES



OAKPORT
Golf Course
County Farm
County Trailer Park
County Cem.
Trailer Park
Sewage Disposal
NORTH
THE
OF
MINNESOTA
NORTH DAKOTA
SCALE 1
CONTOUR INTE

153



SCALE 1:24 000

0 1 MILE

1000 2000 3000 4000 5000 6000 7000 FEET

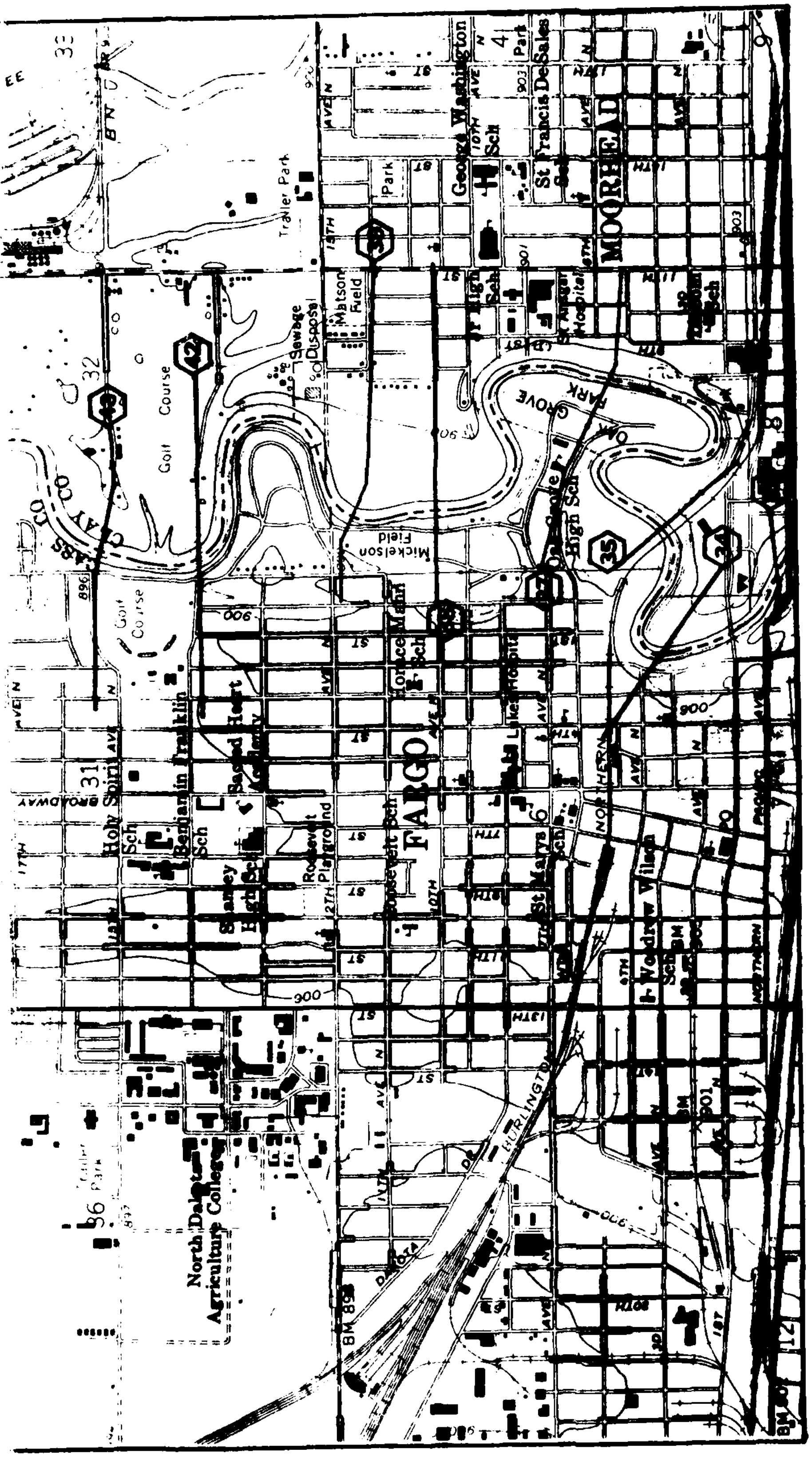
1 0 1 KILOMETER

CONTOUR INTERVAL 5 FEET

FARGO-MOO

Red Riv

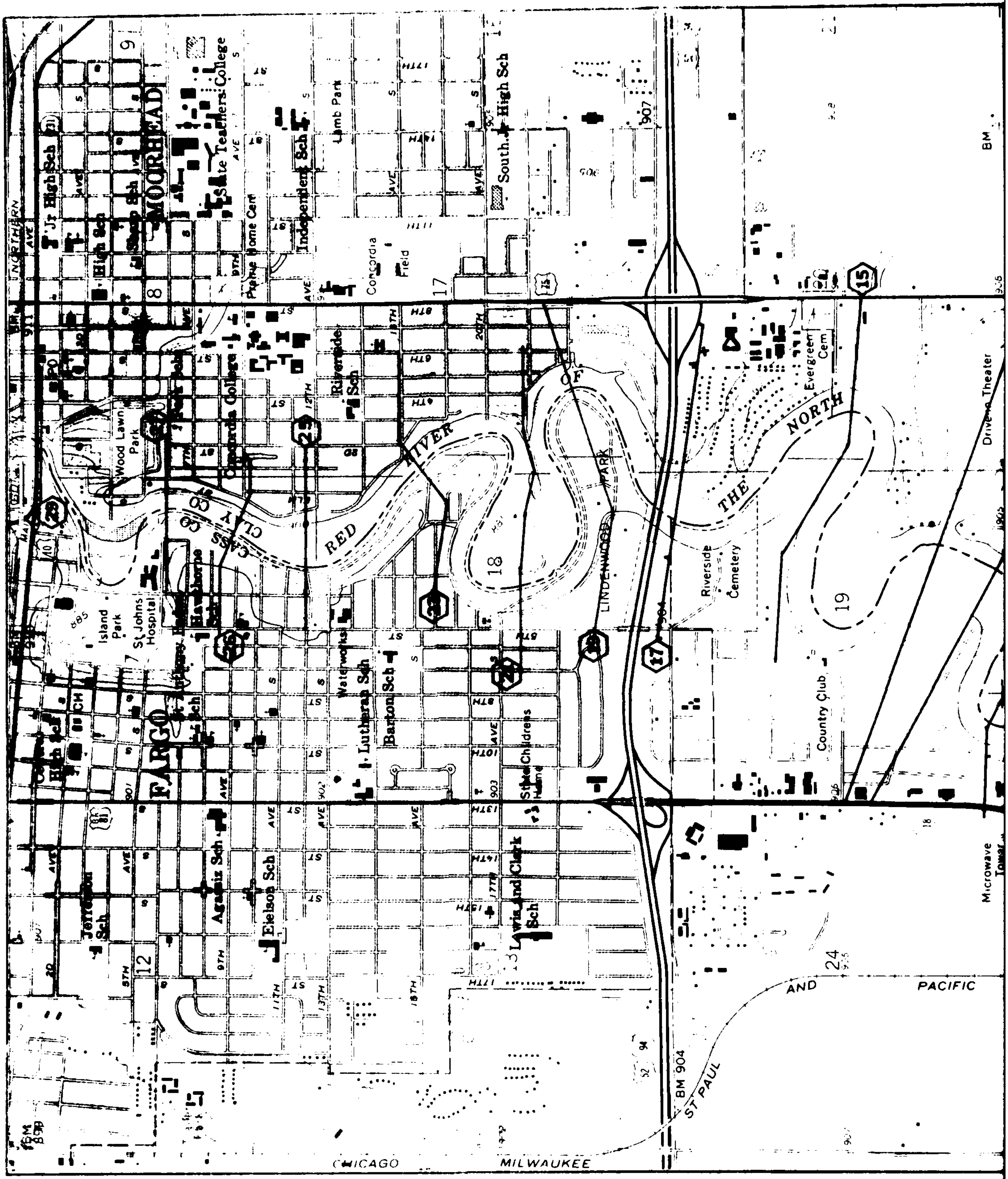
Cross Sec



FARGO-MOORHEAD URBAN STUDY

Red River of the North

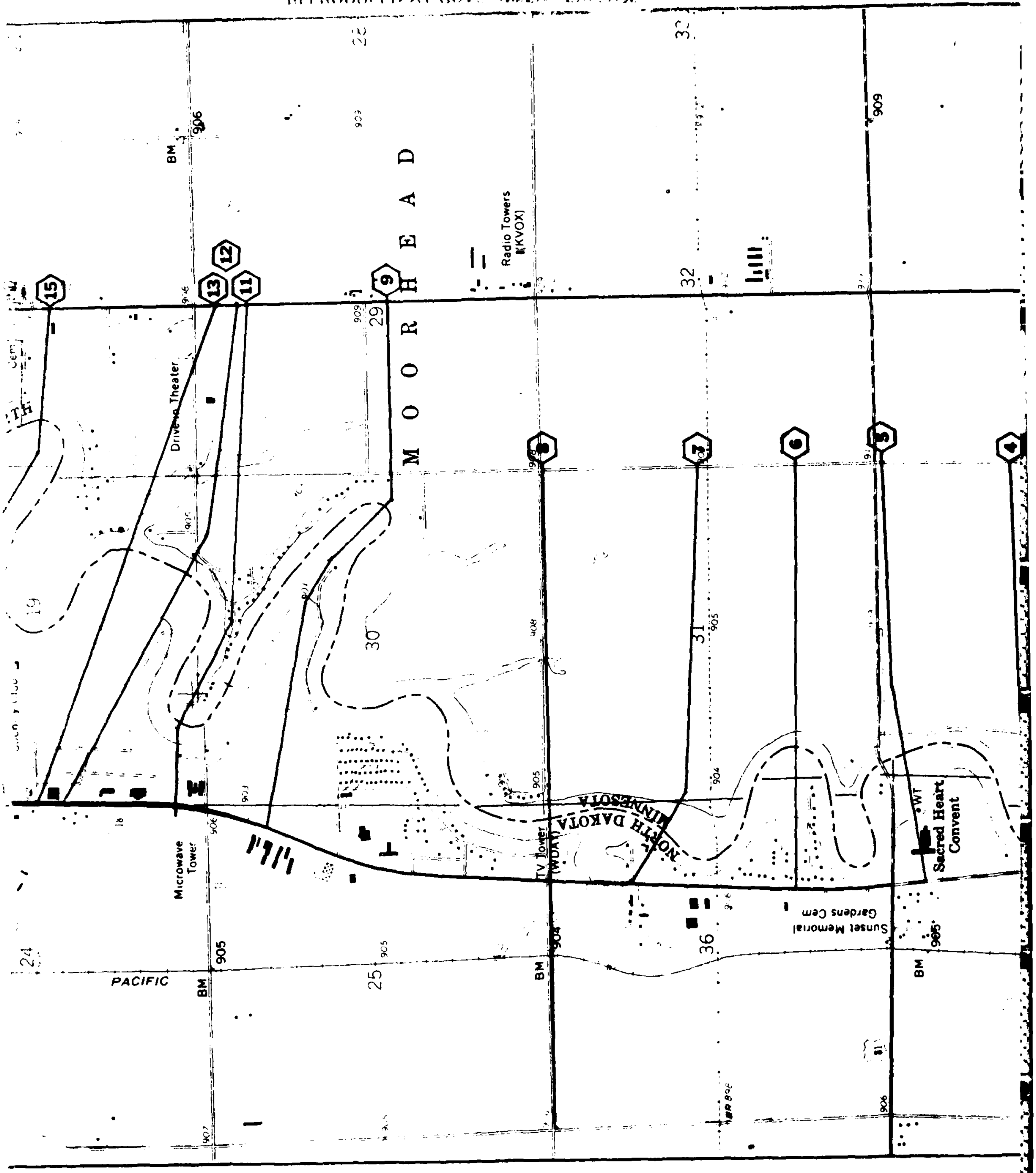
Cross Section Locations



SCALE

1000 0 1000 2000

CONTOUR INT



SCALE 1 24 000

1 MILE

2000 3000 4000 5000 6000 7000 FEET

1 KILOMETER

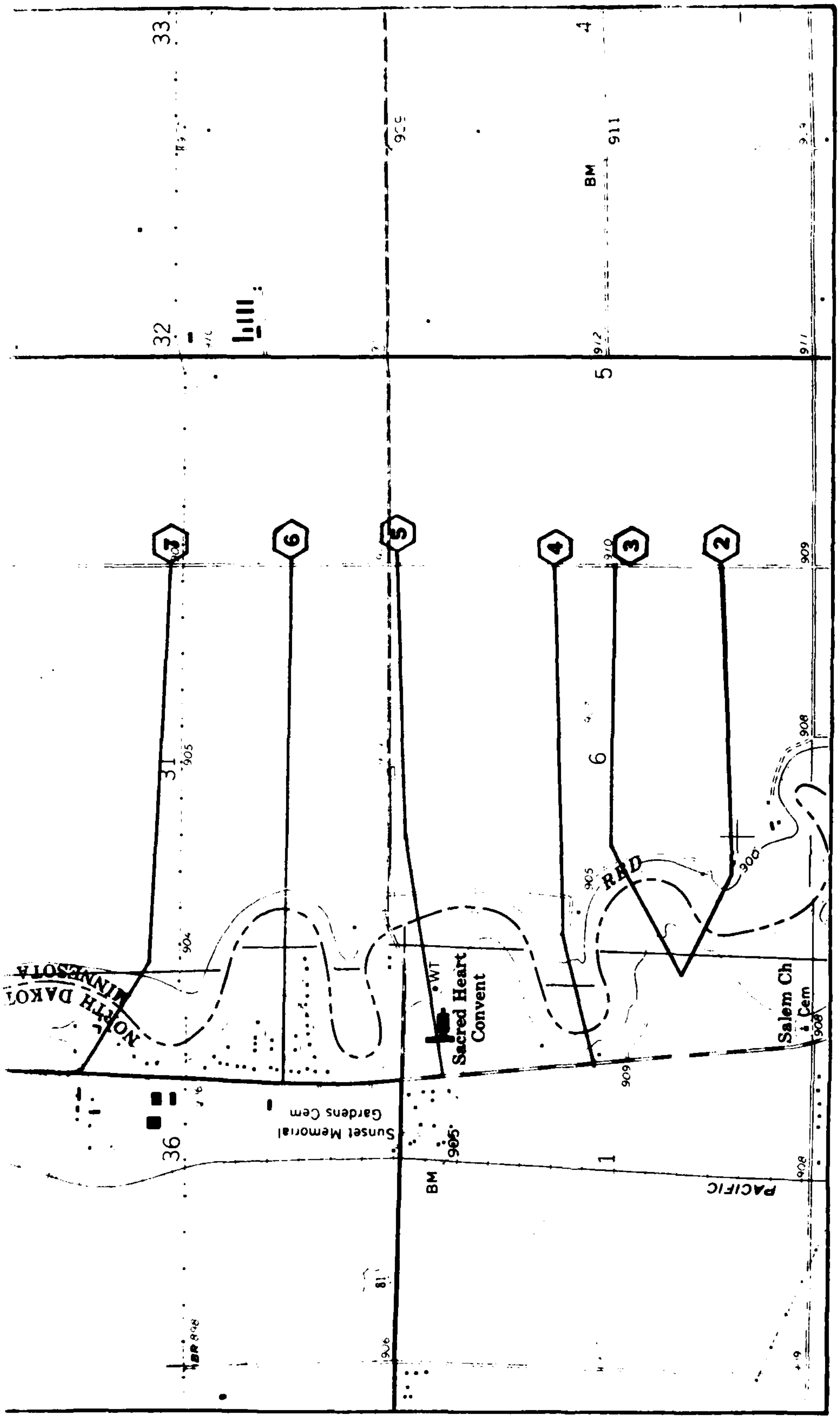
CONTOUR INTERVAL 5 FEET

FARGO

Rec

Cros

29

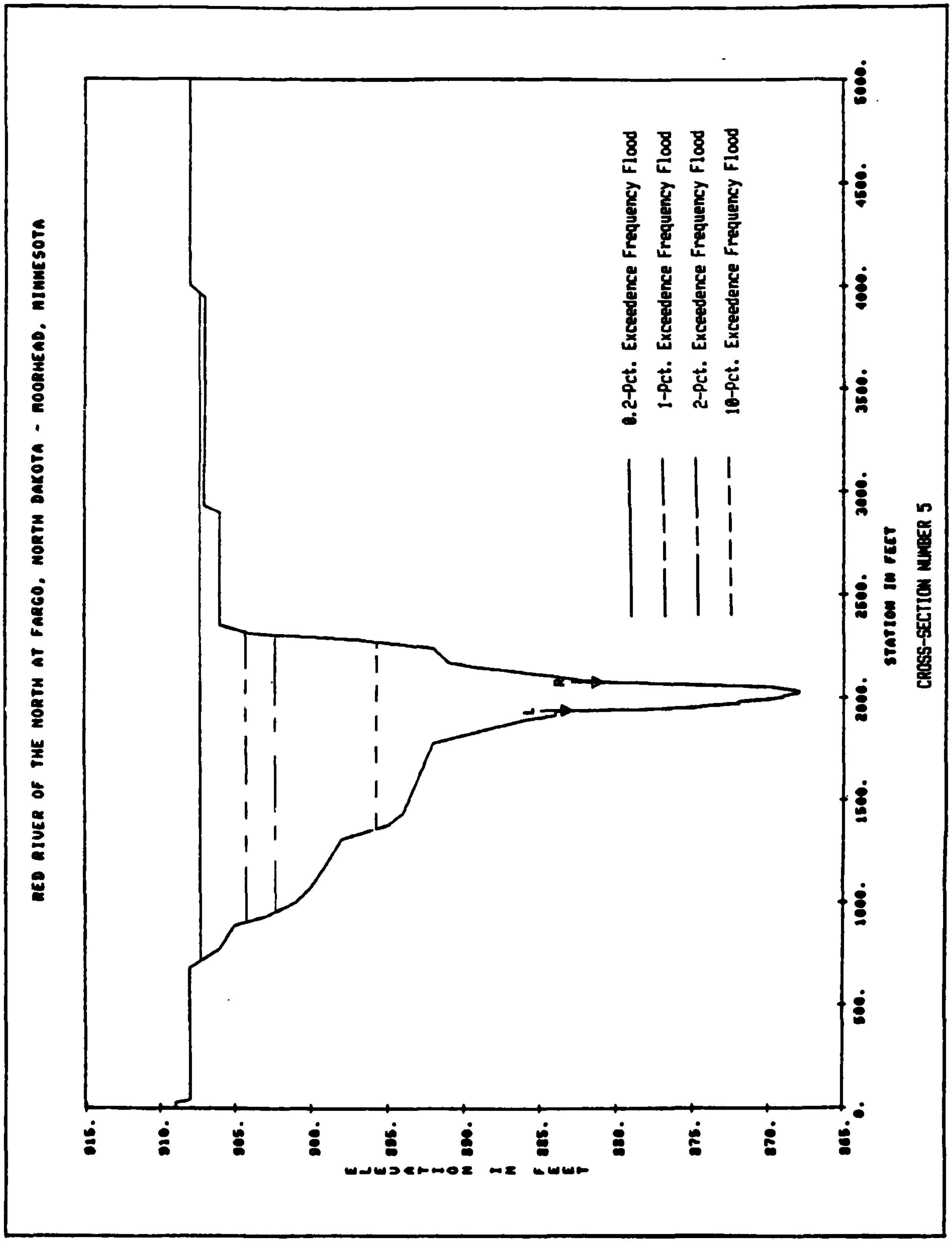


FARGO-MOORHEAD URBAN STUDY

Red River of the North

Cross Section Locations

Plate 3


RED RIVER OF THE NORTH AT FARGO, NORTH DAKOTA - MOORHEAD, MINNESOTA
0.2-Pct. Exceedence Frequency Flood
1-Pct. Exceedence Frequency Flood
2-Pct. Exceedence Frequency Flood
10-Pct. Exceedence Frequency Flood
ELEVATION IN FEET
STATION IN FEET
CROSS-SECTION NUMBER 5
L
R
915.
910.
905.
900.
895.
890.
885.
880.
875.
870.
865.
0.
500.
1000.
1500.
2000.
2500.
3000.
3500.
4000.
4500.
5000.

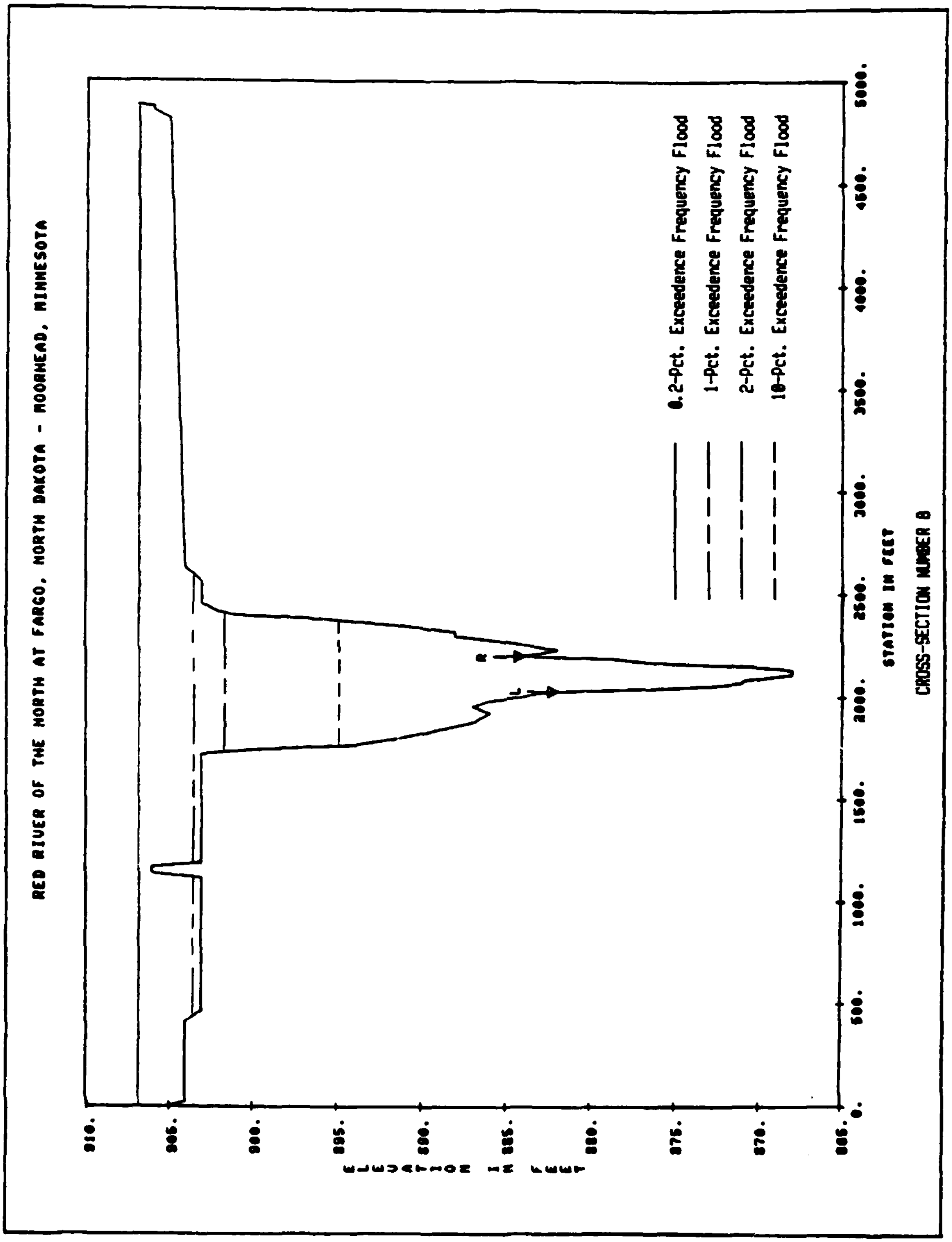

RED RIVER OF THE NORTH AT FARGO, NORTH DAKOTA - MOORHEAD, MINNESOTA
0.2-Pct. Exceedence Frequency Flood
1-Pct. Exceedence Frequency Flood
2-Pct. Exceedence Frequency Flood
10-Pct. Exceedence Frequency Flood
R
L
ELEVATION IN FEET
910.
905.
900.
895.
890.
885.
880.
875.
870.
865.
0.
500.
1000.
1500.
2000.
2500.
3000.
3500.
4000.
4500.
5000.
STATION IN FEET
CROSS-SECTION NUMBER 8

Plate 5

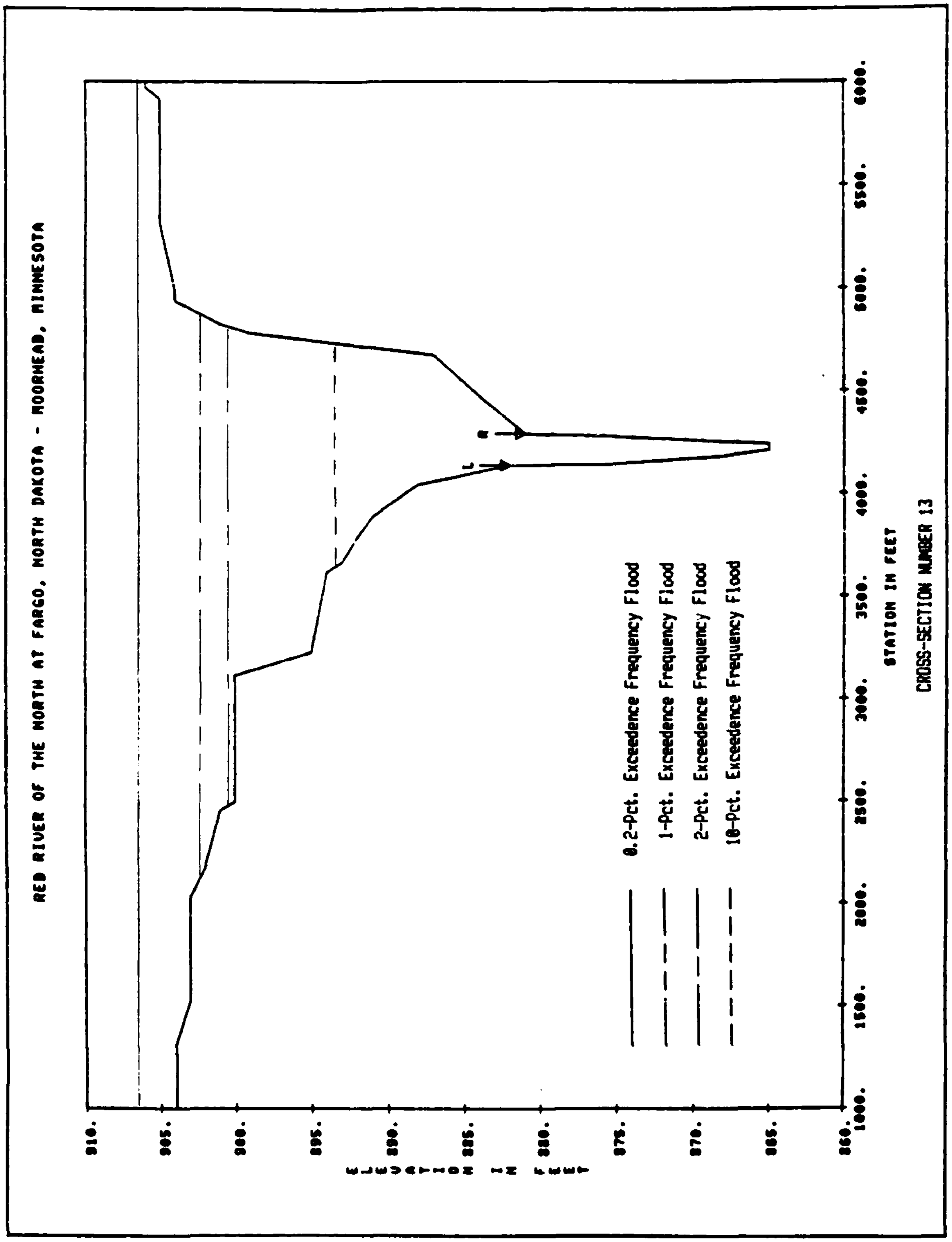
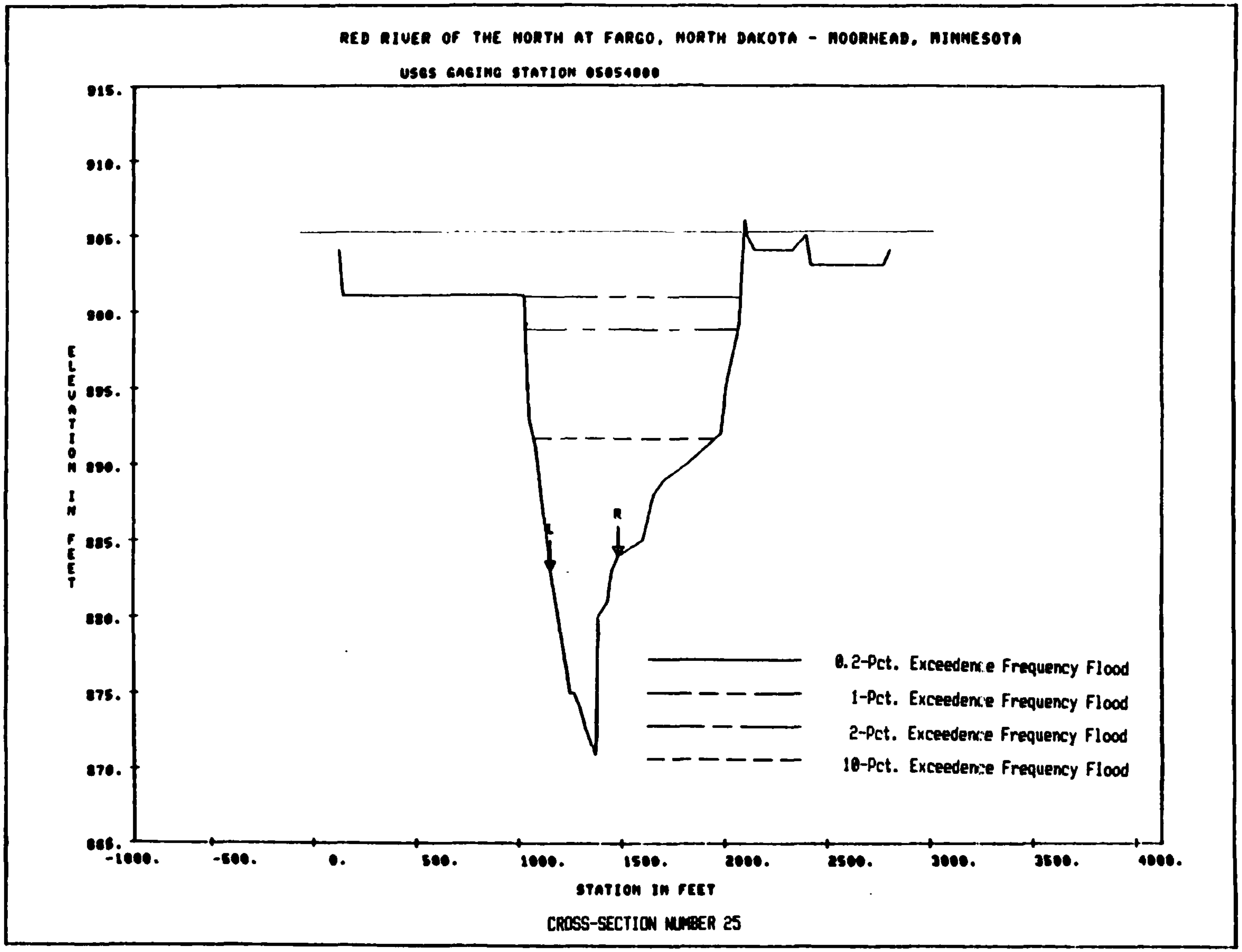

RED RIVER OF THE NORTH AT FARGO, NORTH DAKOTA - MOORHEAD, MINNESOTA
ELEVATION IN FEET
910.
905.
900.
895.
890.
885.
880.
875.
870.
865.
860.
1000.
1500.
2000.
2500.
3000.
3500.
4000.
4500.
5000.
5500.
6000.
L
R
0.2-Pct. Exceedence Frequency Flood
1-Pct. Exceedence Frequency Flood
2-Pct. Exceedence Frequency Flood
10-Pct. Exceedence Frequency Flood
STATION IN FEET
CROSS-SECTION NUMBER 13

Plate 6



RED RIVER OF THE NORTH AT FARGO, NORTH DAKOTA - MOORHEAD, MINNESOTA
USGS GAGING STATION 05054000
ELEVATION IN FEET
915.
910.
905.
900.
895.
890.
885.
880.
875.
870.
865.
-1000.
-500.
0.
500.
1000.
1500.
2000.
2500.
3000.
3500.
4000.
STATION IN FEET
L
R
0.2-Pct. Exceedence Frequency Flood
1-Pct. Exceedence Frequency Flood
2-Pct. Exceedence Frequency Flood
10-Pct. Exceedence Frequency Flood
CROSS-SECTION NUMBER 25

Plate 7

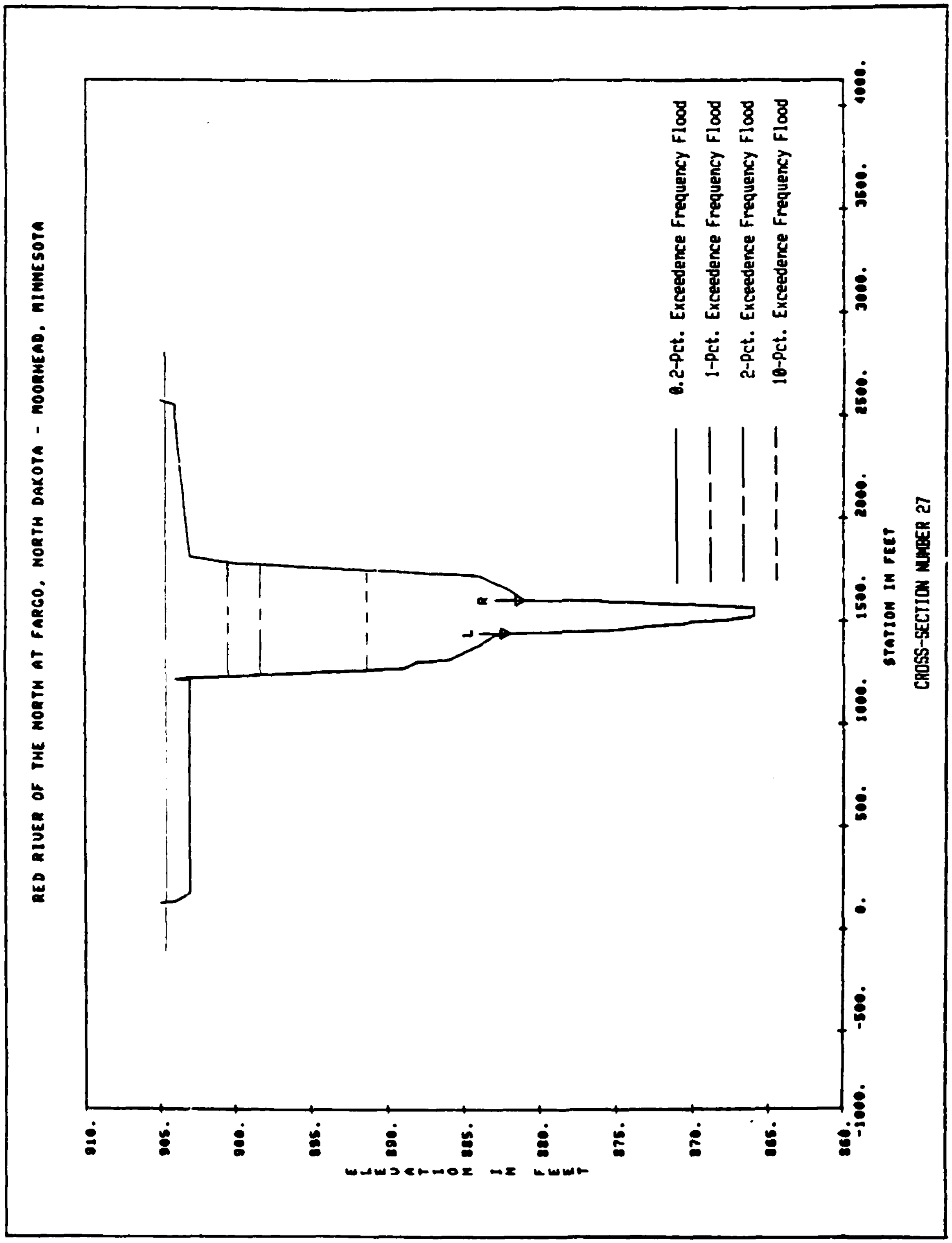
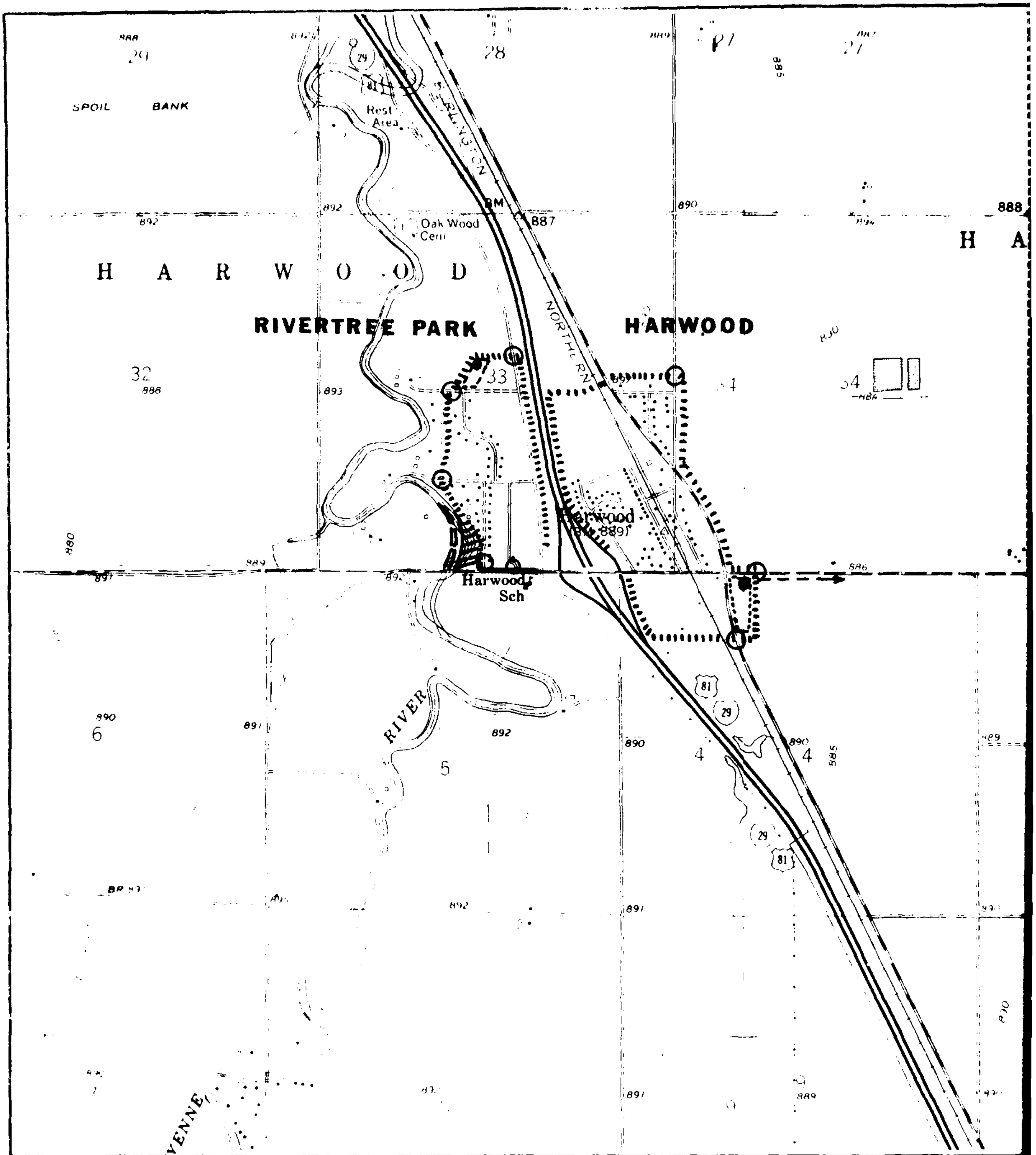
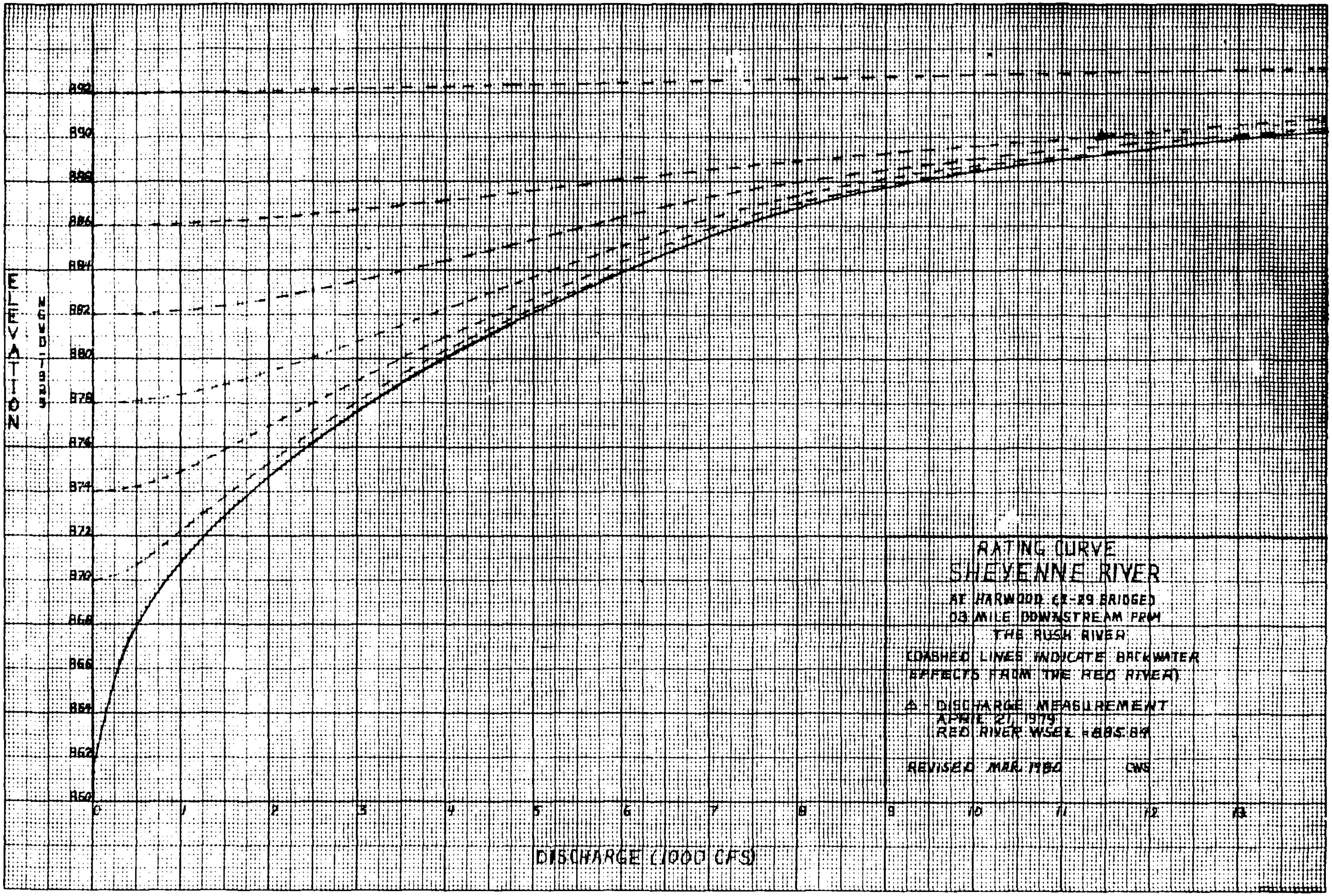

RED RIVER OF THE NORTH AT FARGO, NORTH DAKOTA - MOORHEAD, MINNESOTA
0.2-Pct. Exceedence Frequency Flood
1-Pct. Exceedence Frequency Flood
2-Pct. Exceedence Frequency Flood
10-Pct. Exceedence Frequency Flood
L
R
ELEVATION IN FEET
910.
905.
900.
895.
890.
885.
880.
875.
870.
865.
860.
-1000.
-500.
0.
500.
1000.
1500.
2000.
2500.
3000.
3500.
4000.
STATION IN FEET
CROSS-SECTION NUMBER 27

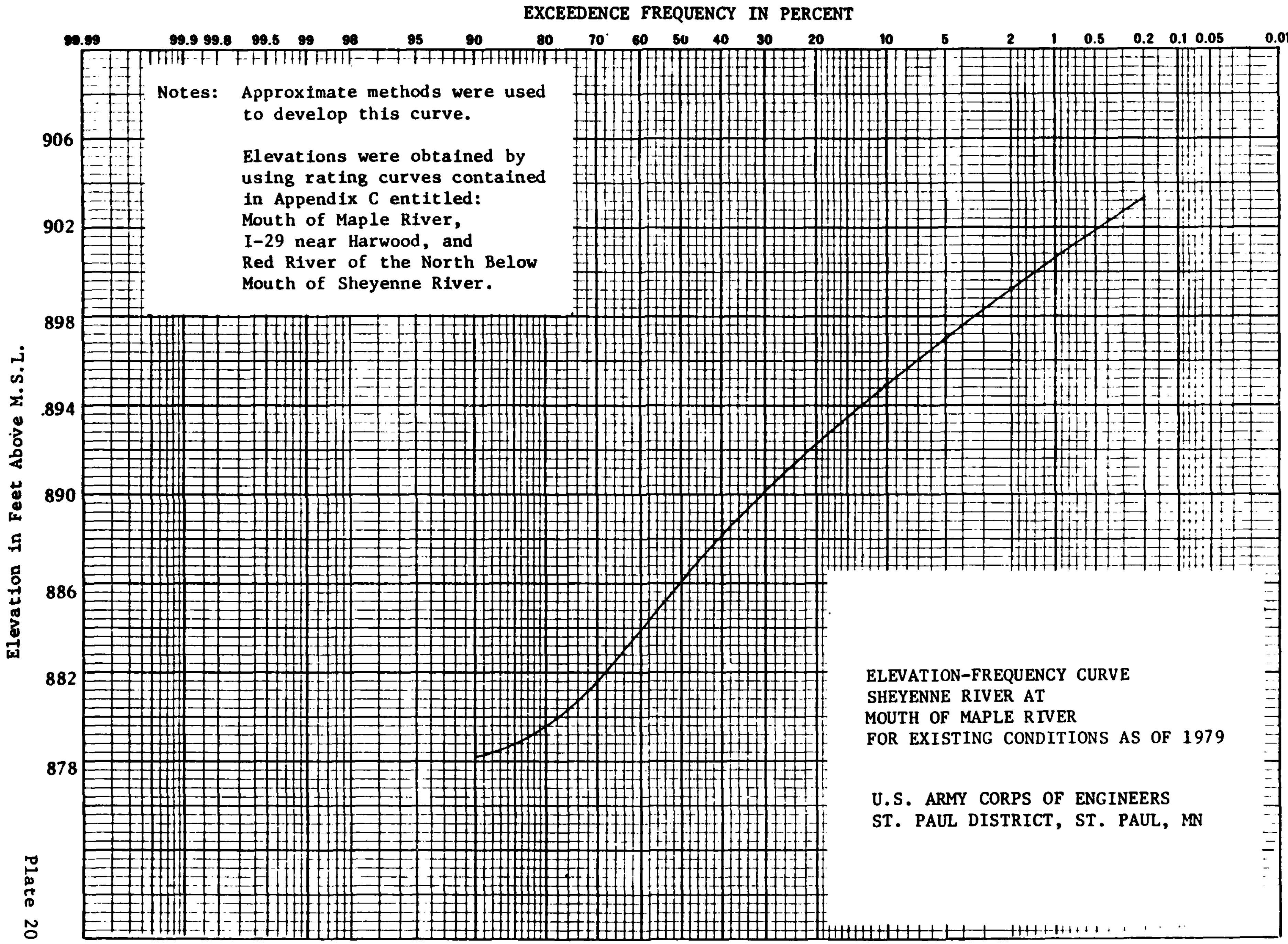
Plate 8



LEGEND

LEVEE
CHANNEL RELOCATION
EMBANKMENT FILL
PONDING AREA
PUMPING STATION
ROAD RAMP
ROAD RAISE


RATING CURVE
SHEYENNE RIVER
AT HARWOOD CR-29 BRIDGE
0.3 MILE DOWNSTREAM FROM
THE RUSH RIVER
(DASHED LINES INDICATE BACKWATER
EFFECTS FROM THE RED RIVER)
△ - DISCHARGE MEASUREMENT
APRIL 27, 1979
RED RIVER WSEL = 885.84
REVISED MAR 1980
CWS
ELEVATION
NGVD-1929
DISCHARGE (1000 CFS)
860
862
864
866
868
870
872
874
876
878
880
882
884
886
888
890
892
0
1
2
3
4
5
6
7
8
9
10
11
12
13



EXCEEDENCE FREQUENCY IN PERCENT
99.99
99.9 99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1 0.05
0.01
Elevation in Feet Above M.S.L.
906
902
898
894
890
886
882
878
Notes: Approximate methods were used to develop this curve.
Elevations were obtained by using rating curves contained in Appendix C entitled:
Mouth of Maple River,
I-29 near Harwood, and
Red River of the North Below Mouth of Sheyenne River.
ELEVATION-FREQUENCY CURVE
SHEYENNE RIVER AT
MOUTH OF MAPLE RIVER
FOR EXISTING CONDITIONS AS OF 1979
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT, ST. PAUL, MN

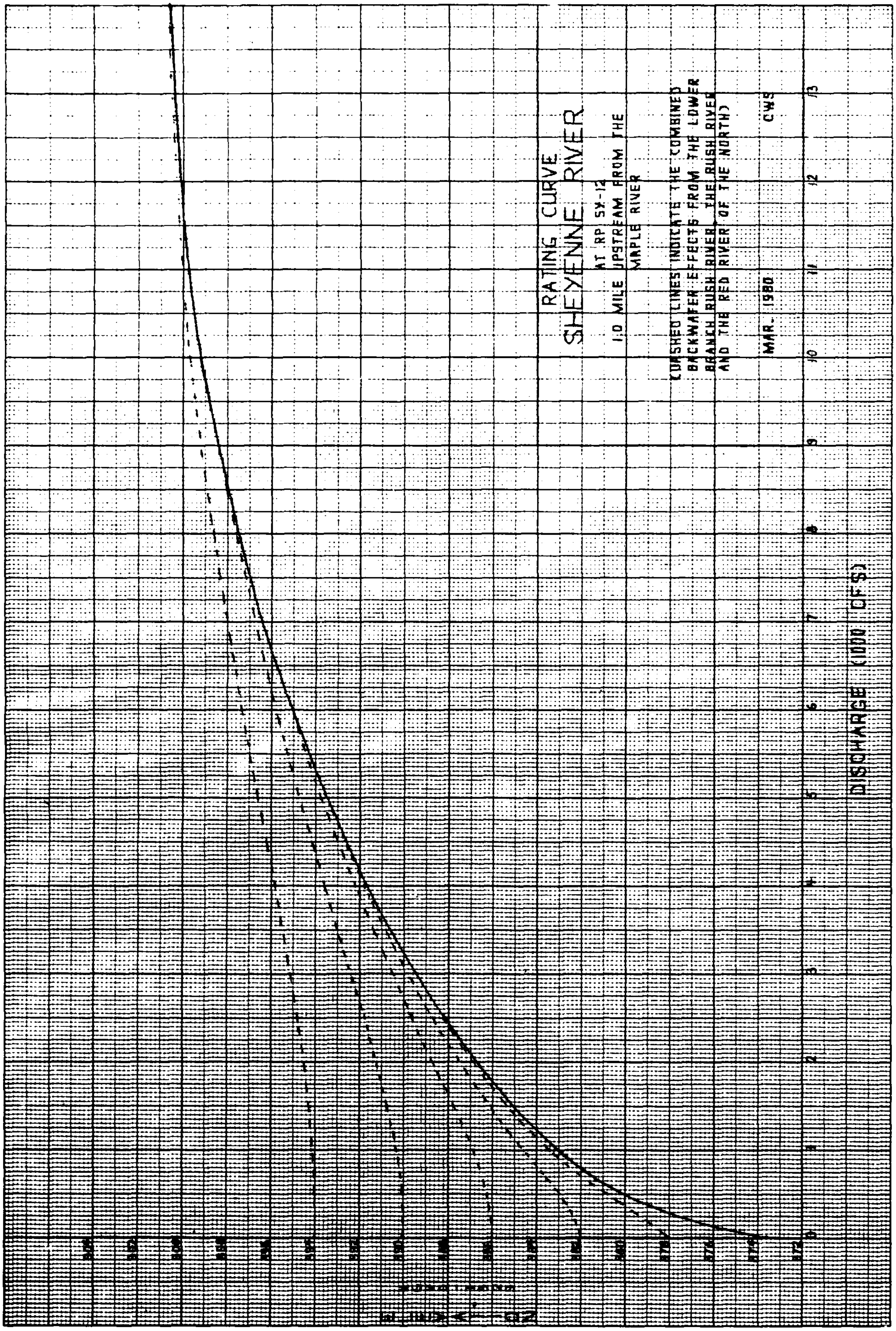
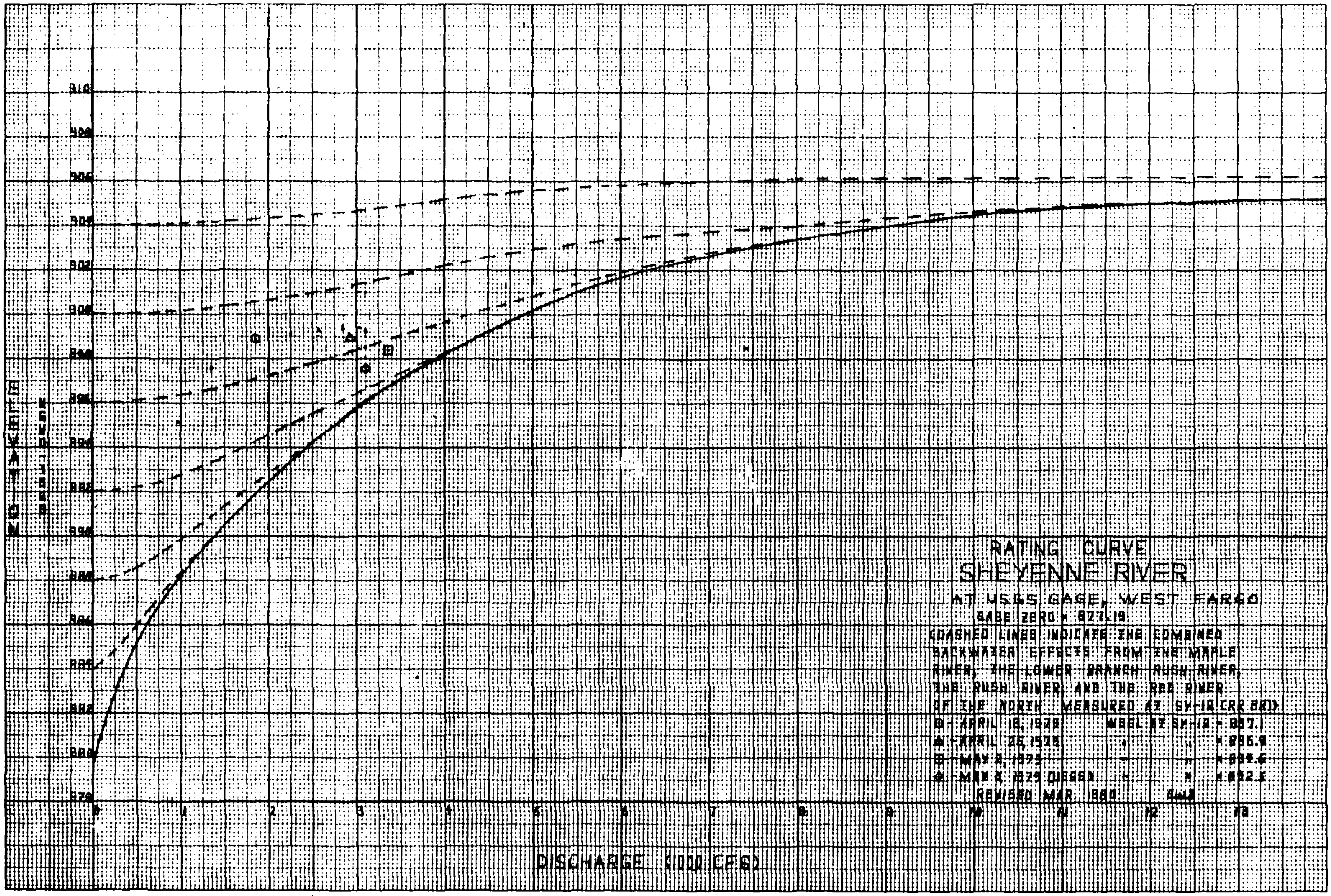
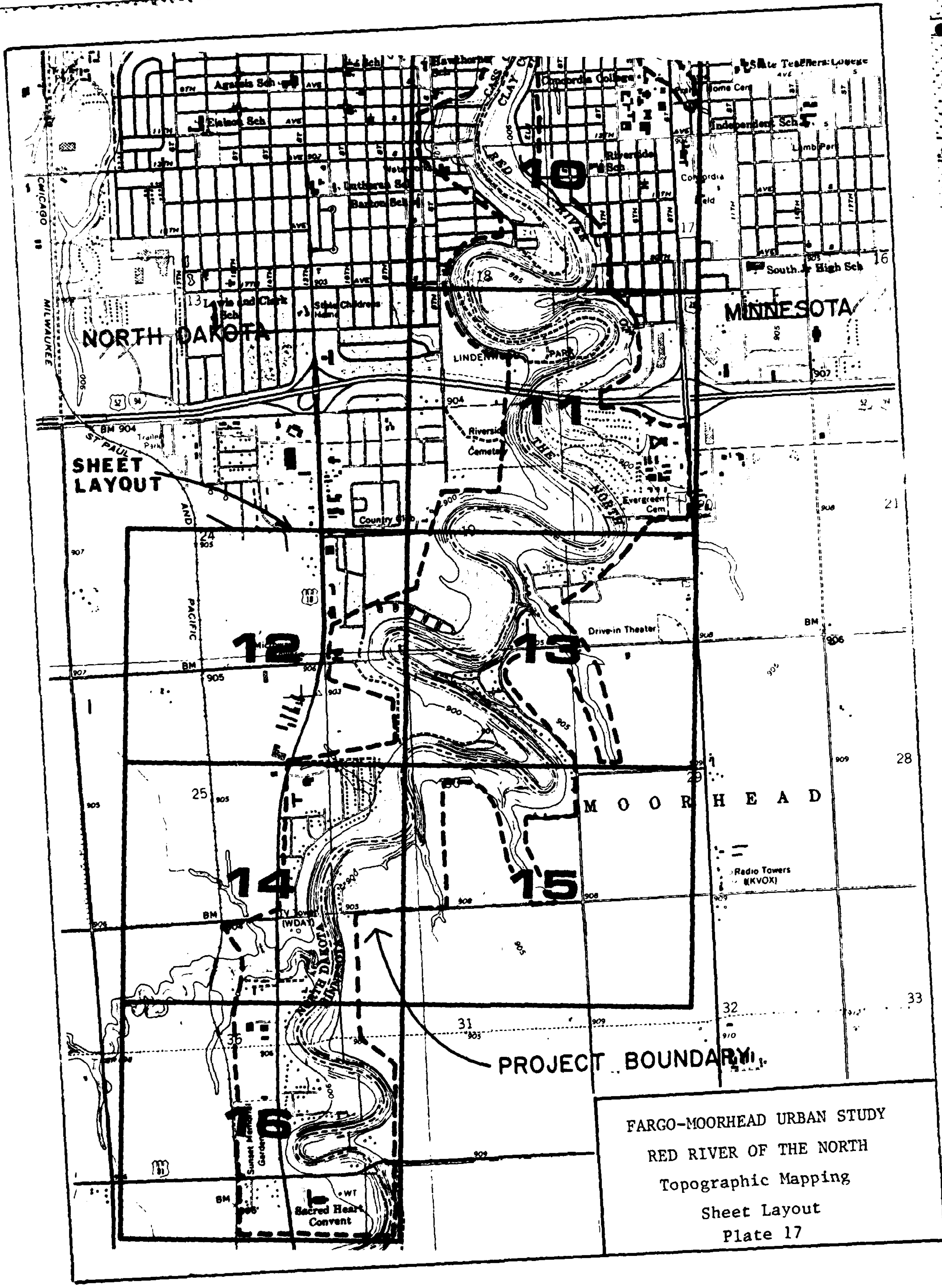

RATING CURVE
SHEYENNE RIVER
AT RP SY-12
1.0 MILE UPSTREAM FROM THE
MAPLE RIVER
(DASHED LINES INDICATE THE COMBINED
BACKWATER EFFECTS FROM THE LOWER
BRANCH RUSH RIVER, THE RUSH RIVER
AND THE RED RIVER OF THE NORTH)
MAR. 1980
CWS
DISCHARGE (1000 CFS)
0
1
2
3
4
5
6
7
8
9
10
11
12
13

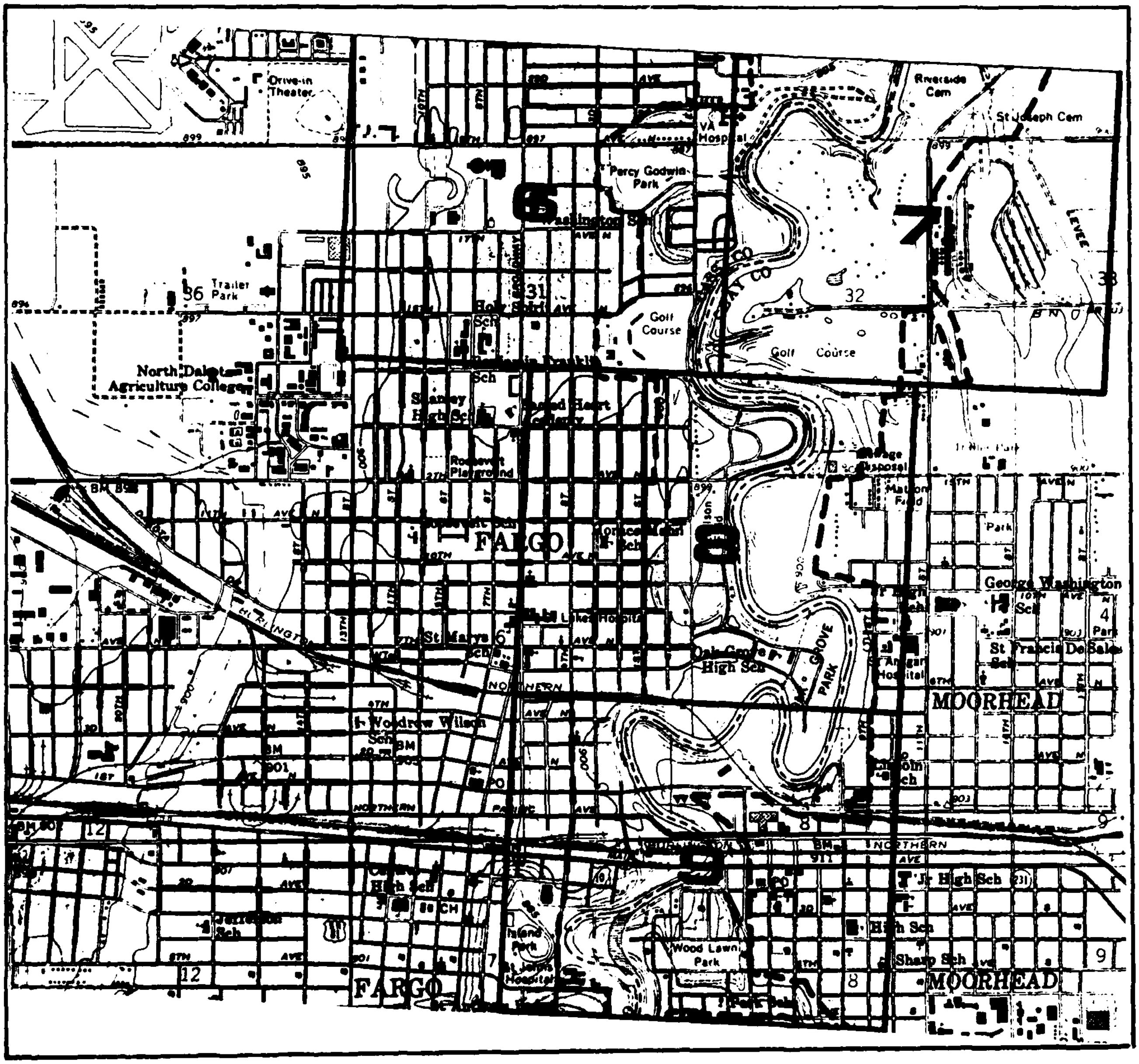
Plate 19



RATING CURVE
SHEYENNE RIVER
AT USGS GAGE, WEST FARGO
GAGE ZERO = 877.19
(DASHED LINES INDICATE THE COMBINED
BACKWATER EFFECTS FROM THE MAPLE
RIVER, THE LOWER BRANCH RUSH RIVER,
THE RUSH RIVER AND THE RED RIVER
OF THE NORTH MEASURED AT SY-18 (RR 88))
APRIL 18, 1979 WSEL AT SY-18 = 897.1
APRIL 25, 1979 = 896.9
MAY 2, 1979 = 894.6
MAY 4, 1979 (USGS) = 892.5
REVISED MAR 1980
ELEVATION
910
908
906
904
902
900
898
896
894
892
890
888
886
884
882
880
878
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DISCHARGE (1000 CFS)



FARGO-MOORHEAD URBAN STUDY
RED RIVER OF THE NORTH
Topographic Mapping
Sheet Layout
Plate 17



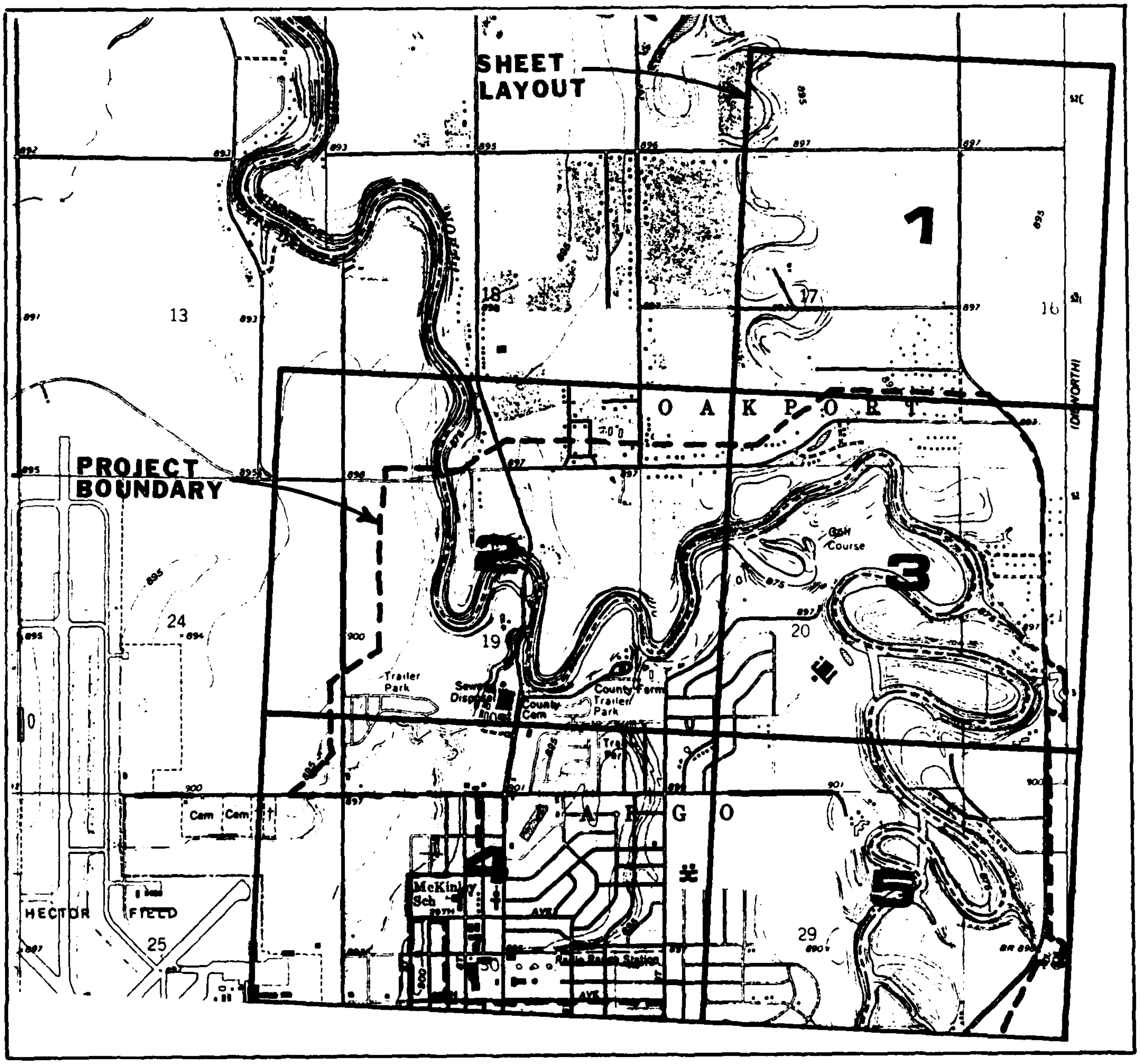
FARGO-MOORHEAD URBAN STUDY

Red River of the North

Topographic Mapping

Sheet Layout

Plate 16



FARGO-MOORHEAD URBAN STUDY

Red River of the North

Topographic Mapping

Sheet Layout

Plate 15

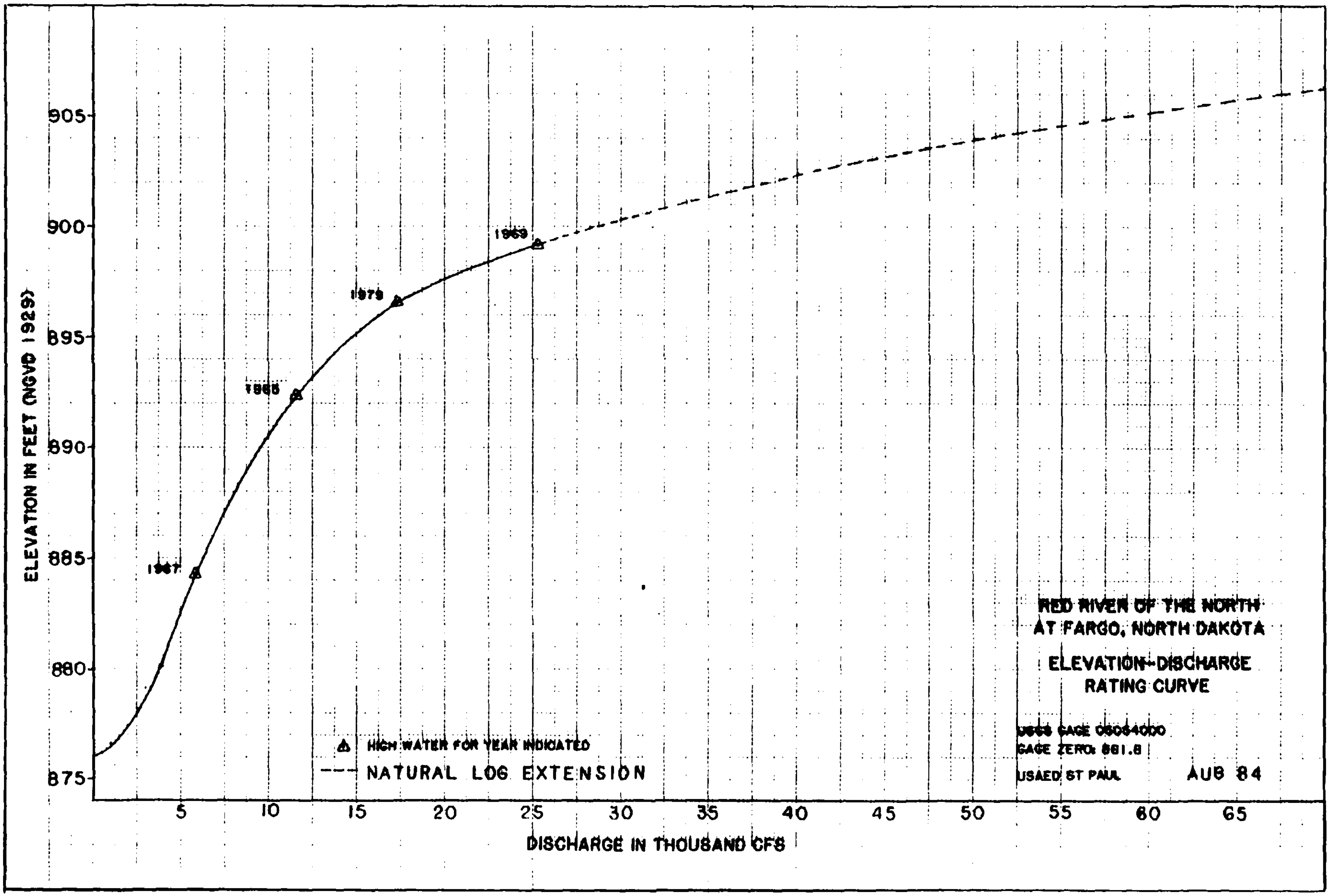
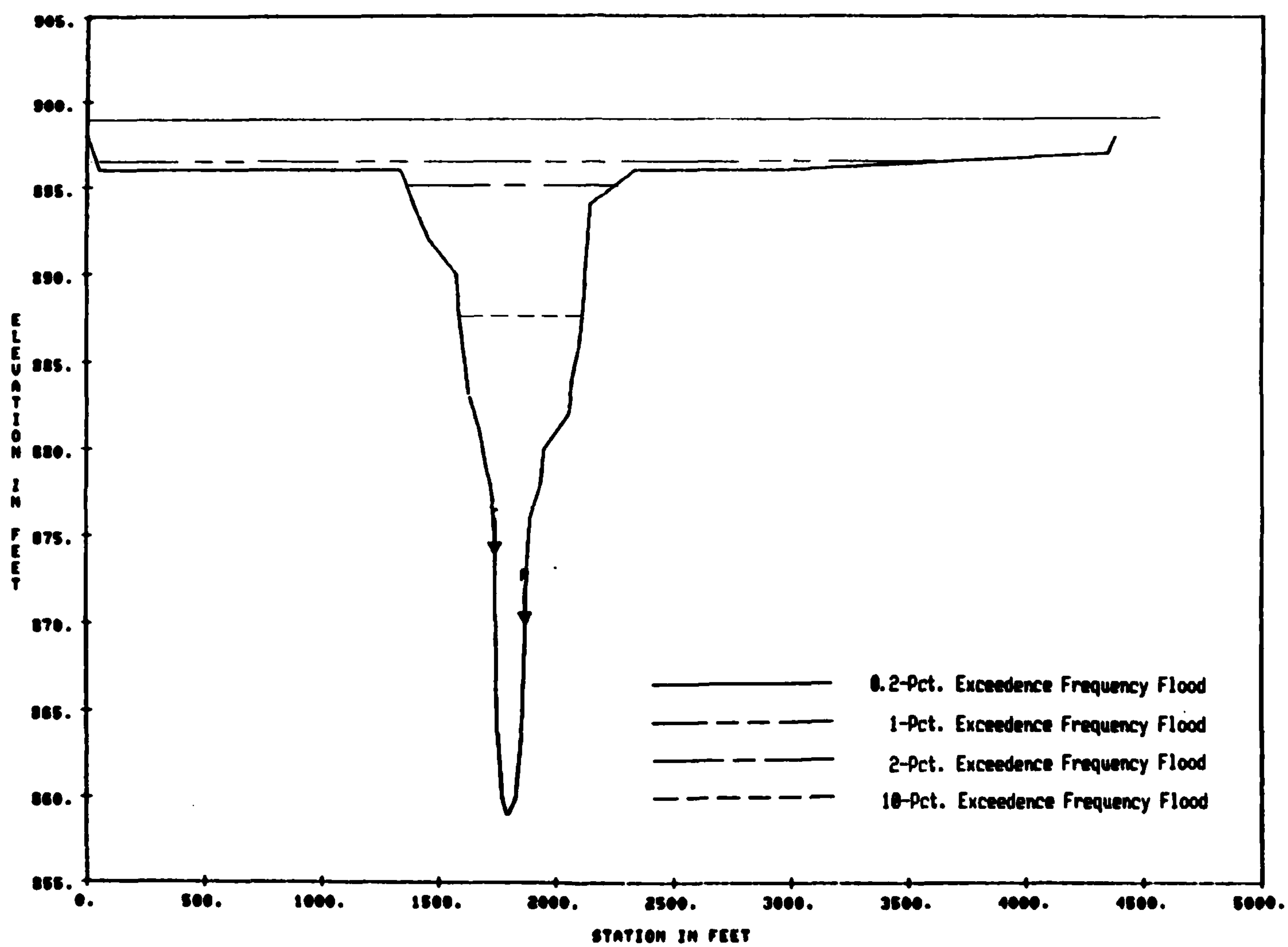

RED RIVER OF THE NORTH
AT FARGO, NORTH DAKOTA
ELEVATION-DISCHARGE
RATING CURVE
USGS GAGE 05054000
GAGE ZERO: 861.8
USAED ST PAUL
AUG 84
HIGH WATER FOR YEAR INDICATED
NATURAL LOG EXTENSION
ELEVATION IN FEET (NGVD 1929)
DISCHARGE IN THOUSAND CFS
1967
1966
1979
1969
905
900
895
890
885
880
875
5
10
15
20
25
30
35
40
45
50
55
60
65

Plate 14

RED RIVER OF THE NORTH AT FARGO, NORTH DAKOTA - MOORHEAD, MINNESOTA



CROSS-SECTION NUMBER 52

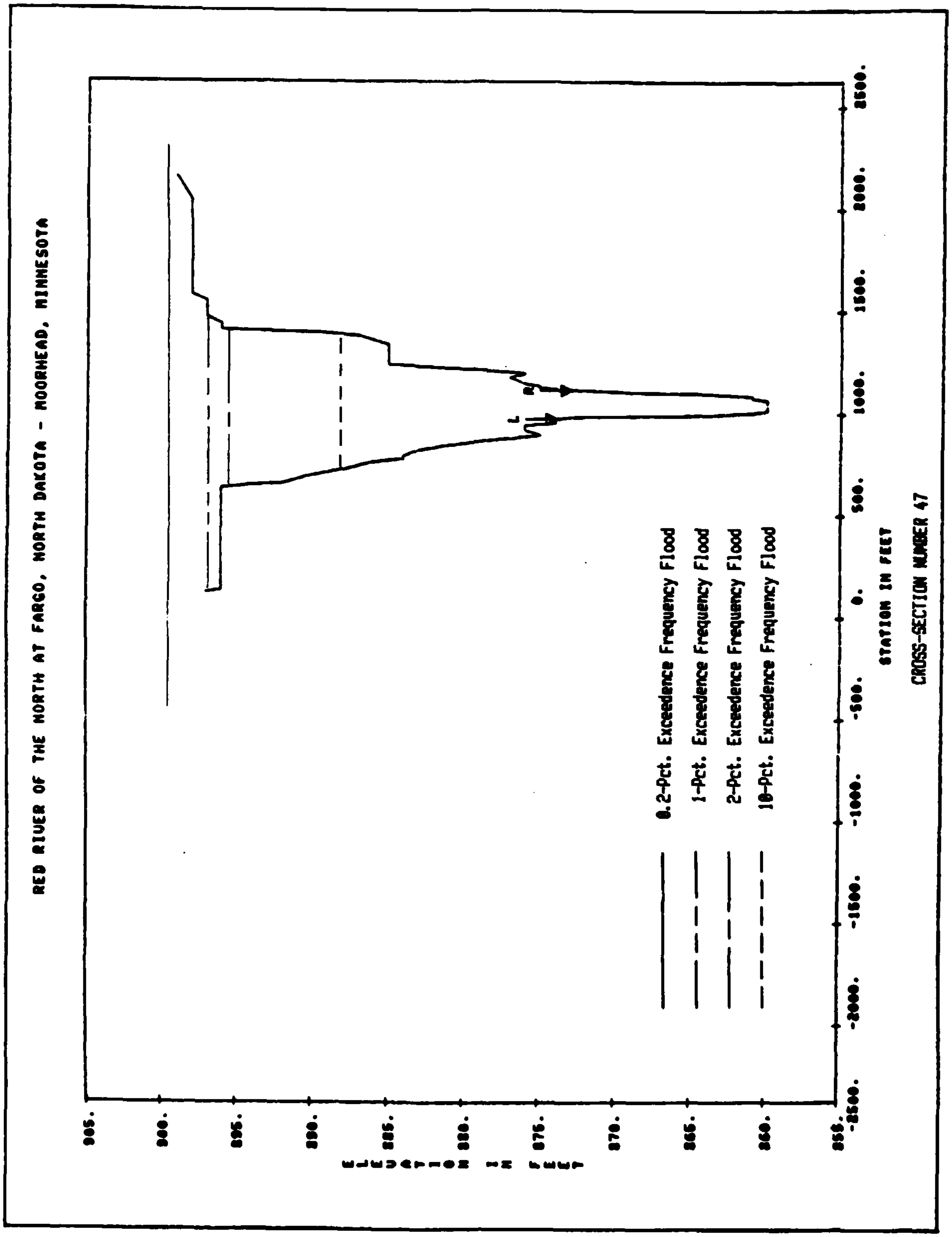
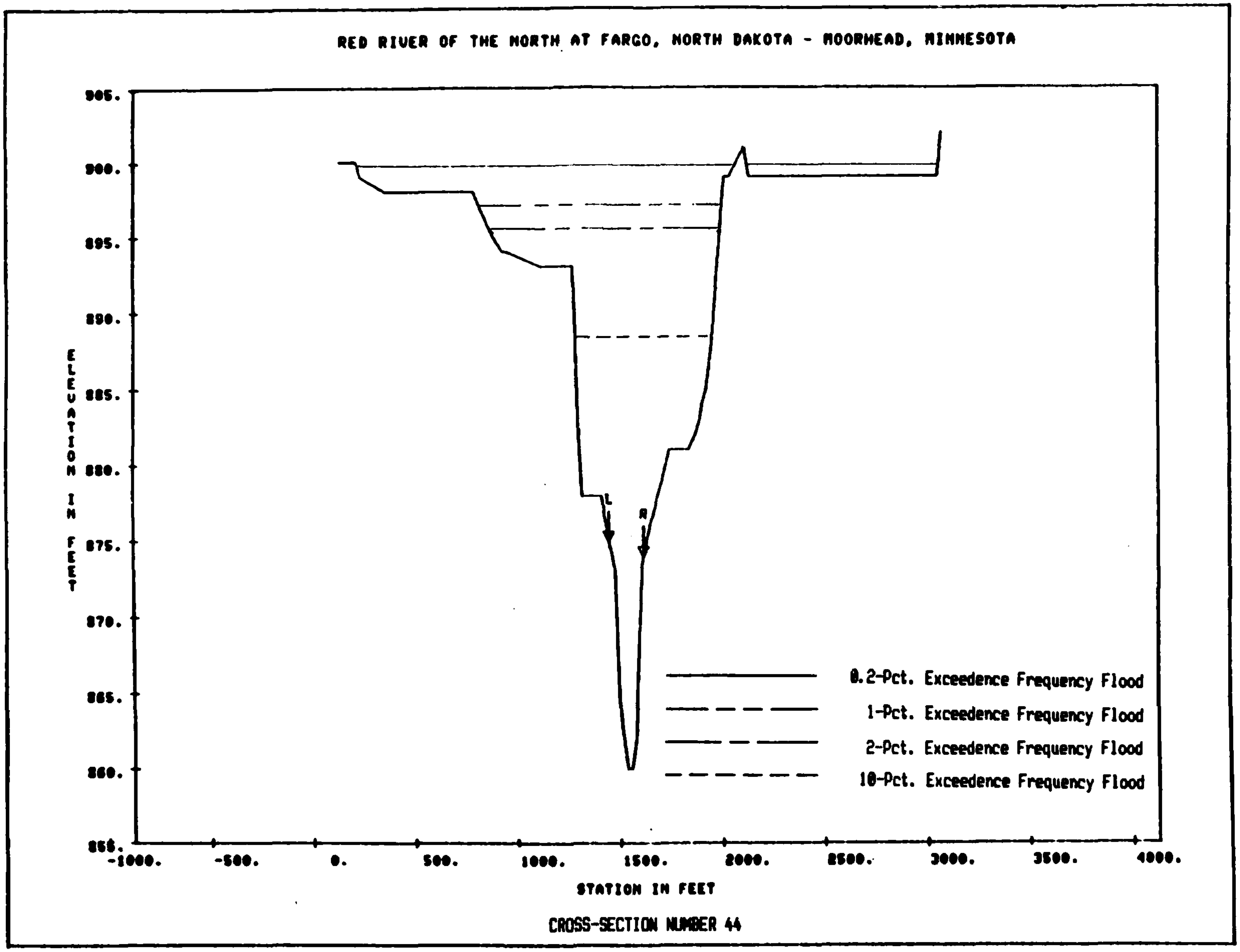
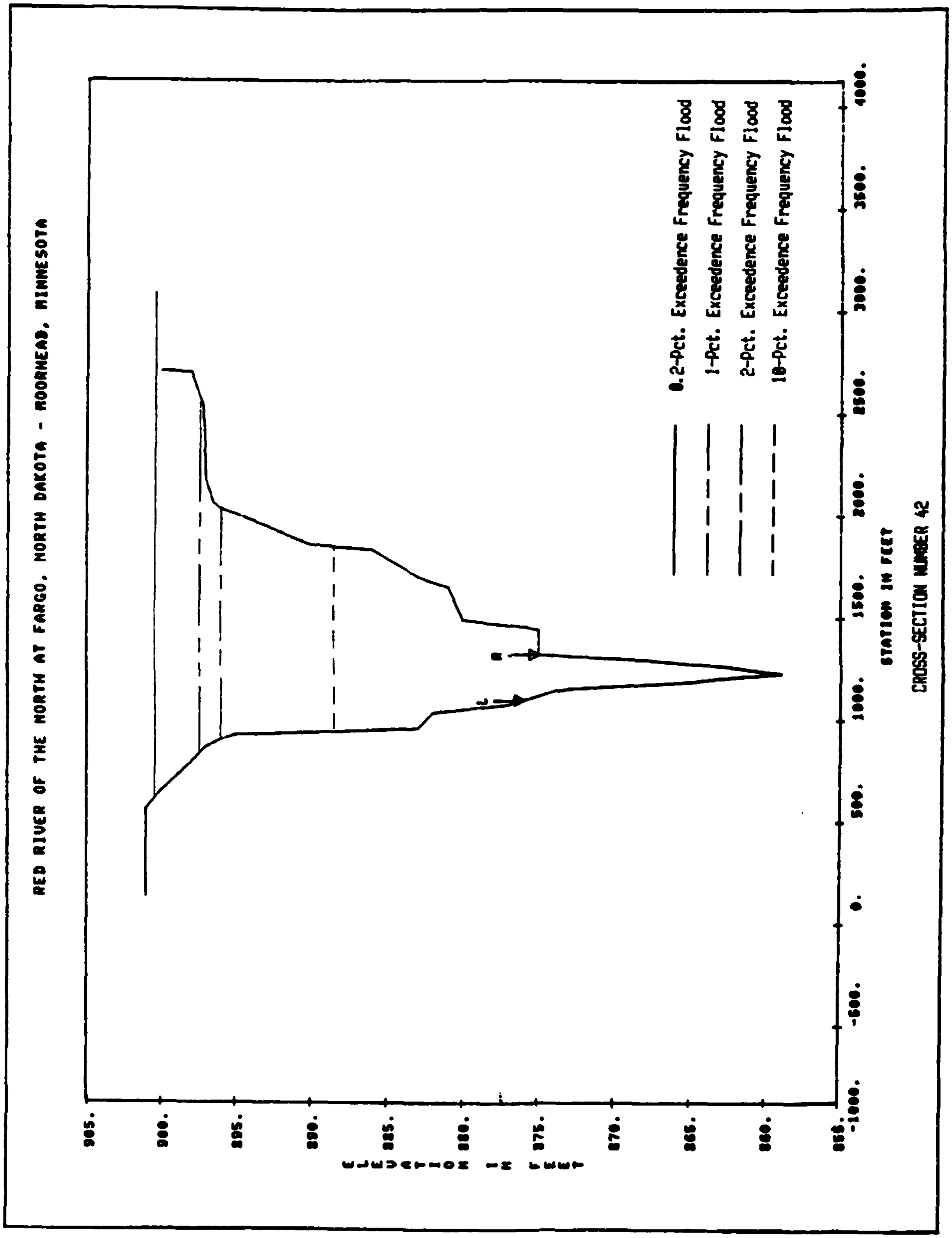

RED RIVER OF THE NORTH AT FARGO, NORTH DAKOTA - MOORHEAD, MINNESOTA
ELEVATION IN FEET
905.
900.
895.
890.
885.
880.
875.
870.
865.
860.
855.
-2500.
-2000.
-1500.
-1000.
-500.
0.
500.
1000.
1500.
2000.
2500.
STATION IN FEET
CROSS-SECTION NUMBER 47
0.2-Pct. Exceedence Frequency Flood
1-Pct. Exceedence Frequency Flood
2-Pct. Exceedence Frequency Flood
10-Pct. Exceedence Frequency Flood
L
R

Plate 12

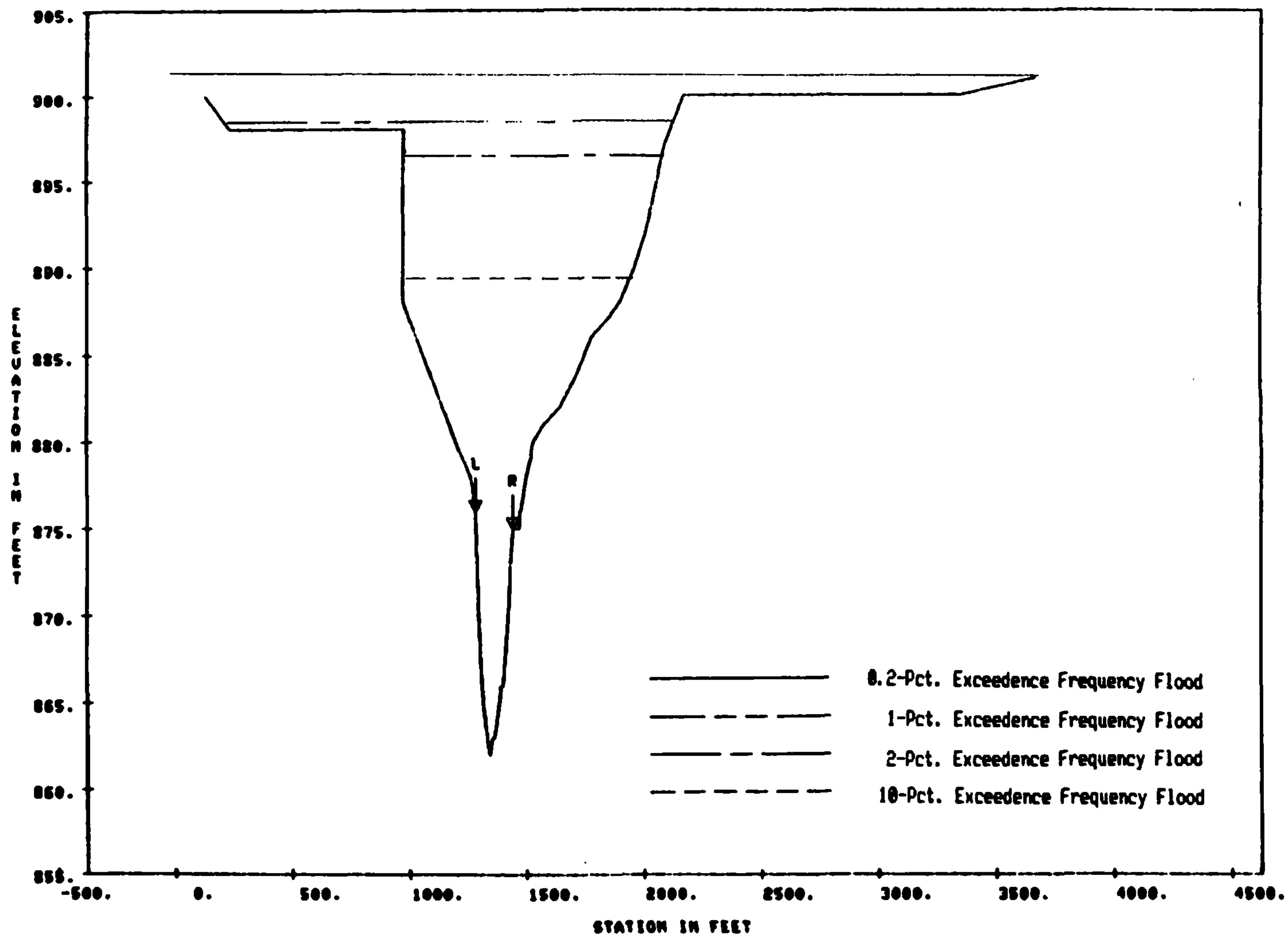

RED RIVER OF THE NORTH AT FARGO, NORTH DAKOTA - MOORHEAD, MINNESOTA
ELEVATION IN FEET
905.
900.
895.
890.
885.
880.
875.
870.
865.
860.
855.
-1000.
-500.
0.
500.
1000.
1500.
2000.
2500.
3000.
3500.
4000.
L
R
0.2-Pct. Exceedence Frequency Flood
1-Pct. Exceedence Frequency Flood
2-Pct. Exceedence Frequency Flood
10-Pct. Exceedence Frequency Flood
STATION IN FEET
CROSS-SECTION NUMBER 44



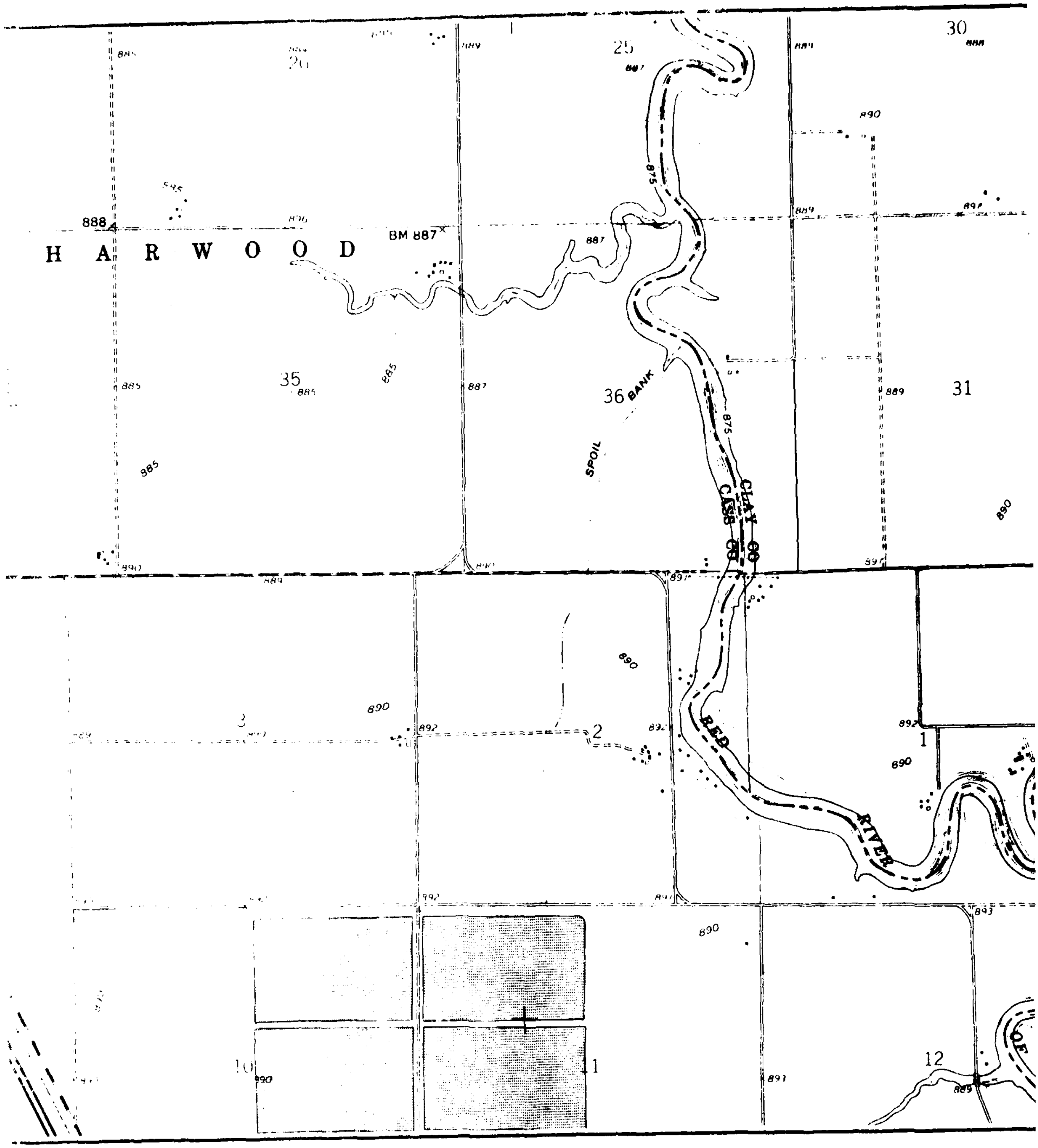
RED RIVER OF THE NORTH AT FARGO, NORTH DAKOTA - MOORHEAD, MINNESOTA
0.2-Pct. Exceedence Frequency Flood
1-Pct. Exceedence Frequency Flood
2-Pct. Exceedence Frequency Flood
10-Pct. Exceedence Frequency Flood
ELEVATION IN FEET
905.
900.
895.
890.
885.
880.
875.
870.
865.
860.
855.
-1000.
-500.
0.
500.
1000.
1500.
2000.
2500.
3000.
3500.
4000.
L
R
STATION IN FEET
CROSS-SECTION NUMBER 42

Plate 10

RED RIVER OF THE NORTH AT FARGO, NORTH DAKOTA - MOORHEAD, MINNESOTA



CROSS-SECTION NUMBER 38

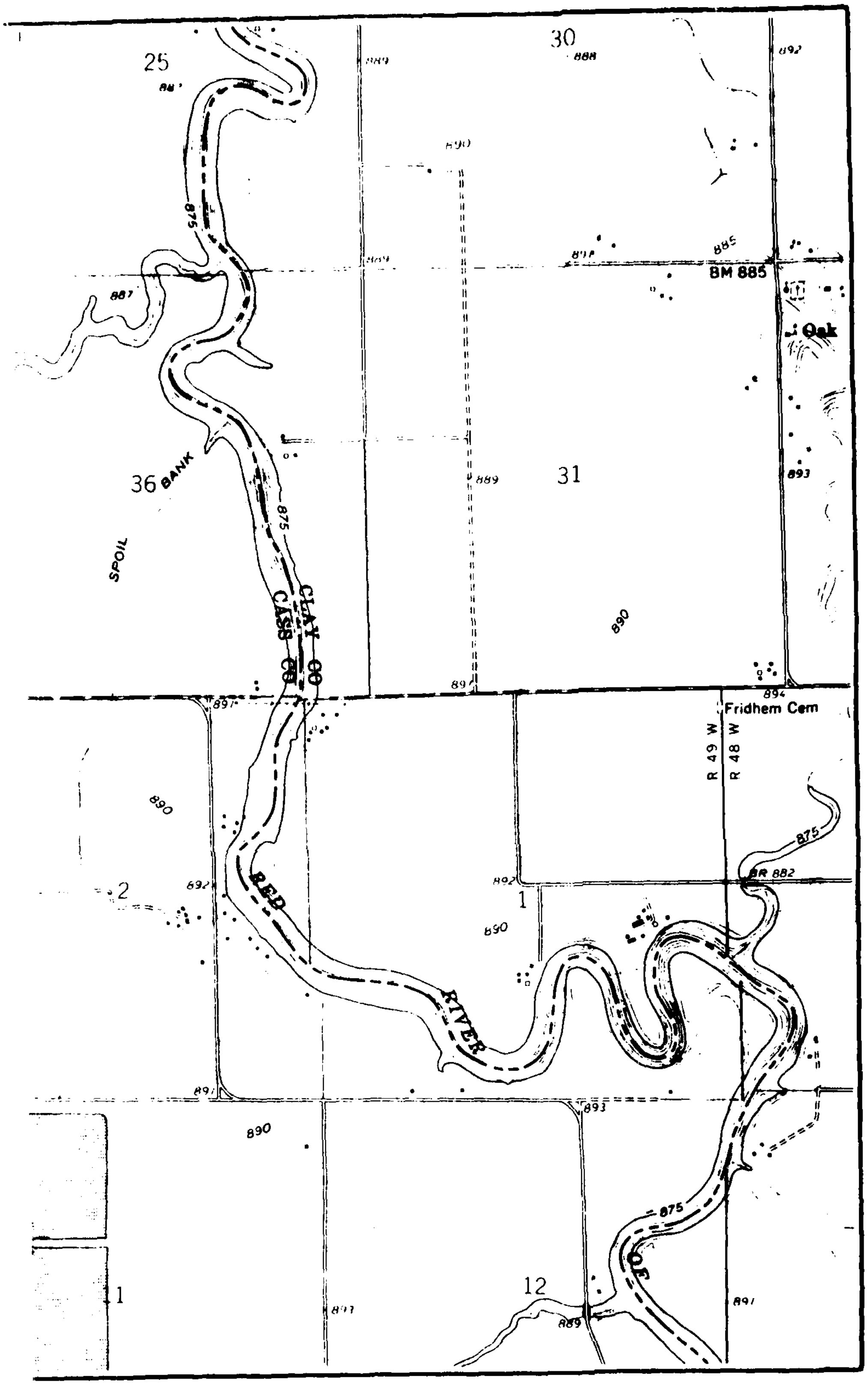


FARGO-MOORHEAD URBAN

FLOOD CONTROL PL

HARWOOD AND RIVERTREE PARK,

293



FARGO-MOORHEAD URBAN STUDY

FLOOD CONTROL PLANS

HARWOOD AND RIVERTREE PARK, NORTH DAKOTA

313

Plate 22

END

FILMED

9-85

DTIC